Design of Rehabilitation Assistive Walking aid Based on Dual-wheel and Four-wheel Switching Structure

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Abstract. Traditional walkers have numerous drawbacks: non-wheeled models are difficult to maneuver, four-wheeled models lack stability, and smart models are prohibitively expensive. This paper presents a walker designed for seamless switching between two-wheel and four-wheel modes. Its rear support features two interchangeable spring modules, enabling two-wheel leaning support and four-wheel propulsion to meet diverse needs. The following sections detail its structure, operating modes, innovations, and cost-effective technical advantages, aiming to create a practical and economical rehabilitation device.

Keywords: Walker; Multi-round switching; Rehabilitation assistance

1 Introduction

The global aging is serious, and the proportion of the elderly population in China is 29.1%. The change of population structure brings pressure to the social support system, and the market demand for walking AIDS increases. However, the mainstream walkers in the market are single in function, stable without wheels but tired in moving, labor-saving with two wheels but need to lift their feet, easy to implement with four wheels but still unstable, and high-end models are expensive and difficult to popularize. Therefore, designing a stable, labor-saving and economical walker is an urgent task in the field of rehabilitation assistance.

2 An Overview of the Theory of Wisdom and Health

For the elderly and those in recovery with limited joint flexibility and weak muscles, traditional walkers fall short. We've designed a walking aid based on the classic two-wheeled walker, using modular and dynamic mode-switching tech. Its rear support feet have spring modules: when resting, the rear wheels lift for stable support and pressure dispersion; when pushing, they lower to form a four-wheel mode, reducing resistance. Users can switch modes naturally with gait pressure changes, ensuring safety and ease. Also, considering the elderly's fear of "losing control," the folding

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structure includes multi-stage buckles and magnetic positioning, reducing error risks and providing a "safe and controllable" feeling[1].

3 Analysis of Existing Products for Walker Design

3.1 Walker Classification

In this study, according to the structure and motion mode, mechanical walkers are divided into three types: frameless, two-wheeled and four-wheeled Wheelless frame is supported by rectangular frame, which needs to be lifted when moving, and the structure is simple and stable; Two-wheeled front wheel rear support foot, easy to move, but the rear needs to be lifted manually; Four-wheel full-roller design, labor-saving, but slightly weak stability. The three types have their own advantages in "stability" and "mobility" and are suitable for different scenarios. The following table will compare their key characteristics(see Table 1).

Table 1. Classification characteristics of unpowered walkers

Product illustration	Category	Applicable crowd	Advantages	Disadvantages
	Wheelchair-free walking aid	Poor balance, early postoperative rehabilitation and need strong static support.	Good static stability, reliable support, simple structure and low cost.	It is not suitable for people with long distance or poor physical strength because of fatigue and low efficiency of upper limbs caused by complete lifting when moving.
	Two-wheeled walker	Users who need to give consideration to certain support and movement and have acceptable upper limb strength.	The front wheel rolling is more labor-saving than the wheelless movement, and the static stability of the rear foot support is good.	When moving, it is necessary to lift the hind foot without Jiefang Quan's upper limb, which is a compromise of function and poor adaptation to complex scenes.
	Four-wheeled walker	Balance is acceptable, often moving in short distances and seeking convenience.	The implementation of labor-saving and smooth movement, often equipped with a seat storage basket with multiple functions and flexible steering.	Poor static stability has the risk of rollover, which requires high balance control and high price.

Although the traditional mechanical two-wheeled walker is widely used, it balances static stability and convenient movement, but it needs to be partially lifted when moving, the problem of upper limb load is not completely solved, and its function is limited.

The two-wheel/four-wheel switchable walker improves the traditional two-wheel structure and can flexibly switch between stable support and easy movement, which is suitable for the elderly and rehabilitation people who often stop walking indoors and outdoors. It replaces complex electric control with simple spring mechanism, which

has low cost, high reliability and can adapt to the environment. This scheme breaks through the limitations and has modular potential, which is a practical, safe and economical choice to deal with aging.

3.2 Development Status of Walker

In the global elderly assistive device R&D market, the Asia-Pacific region leads in growth, though Europe and America remain dominant. Experts forecast the global medical walker market to grow at a 5.25% compound annual rate from 2024 to 2029, boosting the household walker market and aligning industry supply with consumer needs. [2] The walker industry's development differs globally: developed regions like Europe, America, and Japan have extensive aging experience, mature R&D, and industrial chains, with ongoing technological advancements. In contrast, China, with large domestic demand but a late start, mainly produces basic models, lacking in key areas and with incomplete standards, leaving the high-end market to imports. China is now focusing on imitation and improvement, needing to strengthen basic material research, promote doctor-worker cross-innovation, and establish aging standards to bridge the gap.

4 User Experience Analysis of Multi-Wheel Switching Walker in the Situation of Home Care for the Elderly

4.1 Behavior Demand Analysis

In the design of walkers, the analysis of environmental situation is very important to clarify the requirements and adaptation functions, and the differences between indoor and outdoor physical environments make the performance requirements of walkers different. [3] The interior design needs to consider the wheel surface anti-skid, compact structure and flexible steering to adapt to the narrow space, and can smoothly cross low obstacles. Outdoor terrain is complex, ramps and potholes need low center of gravity or anti-dumping structures, gravel and muddy roads require strong passability, and public facilities affect portable and folding functions, so it is necessary to give consideration to lightweight and rapid retraction.

4.2 Analysis of Psychological Needs

Walker design should cater to the psychological needs of the elderly. [4] Many seniors aim to preserve their self-worth and social ties through self-care, so walkers should aid in "maintaining independence and reducing reliance." Functionally, they should offer control, like adjustable support, flexible steering, stable obstacle navigation, and user-friendly operations such as one-button folding, lightweight materials, and ergonomic grips, minimizing the "disabled assistance" stigma. Aesthetically, they should be practical yet attractive, avoiding stark designs and dull colors that heighten alienation. Simple lines, soft neutral hues, or customization can transform seniors from passive

"assisted dependents" to active "self-empowered" individuals, fostering a positive action identity.

5 Design Practice of Walker Based on Ergonomics

5.1 User Situation-Oriented: the Switching Mode Conforms to the Physiological and Psychological Needs

For the elderly and those in recovery with limited joint flexibility and weak muscles, traditional walkers fall short. We've designed a walking aid based on the classic two-wheeled walker, using modular and dynamic mode-switching tech. Its rear support feet have spring modules: when resting, the rear wheels lift for stable support and pressure dispersion; when pushing, they lower to form a four-wheel mode, reducing resistance. Users can switch modes naturally with gait pressure changes, ensuring safety and ease. Also, considering the elderly's fear of "losing control," the folding structure includes multi-stage buckles and magnetic positioning, reducing error risks and providing a "safe and controllable" feeling.

5.2 Environmental Situation Orientation: Structural Transformation Fits the Use of Home-Based Pension Scenarios

Based on the limited space and complex functions of home care for the aged, we optimized the structural transformation of the walker to make it flexibly adapt to the home environment and become a dynamically adjustable support system.

Considering the different heights of furniture, the armrest of the walker can be rotated and adjusted, the height can be continuously raised and lowered between 75 and 95 cm, and the end can be extended by 15 cm to help the elderly maintain stability. [5] This design allows the walker to adapt to the home, reduces the transformation of the living environment, and also relieves the psychological rejection of the elderly, realizing the dual adaptation of physics and psychology.

5.3 Man-machine Situational Orientation: Functional Integration to Optimize the Use Experience

Following the man-machine situation-oriented design concept, [6] this scheme takes the elderly users as the center, and optimizes the function of the walker from "intuitive operation" and "scene adaptation" to enhance the use experience. In view of the confusing operation, the decentralized functions are integrated into a concise and intuitive operation form, and there are clear feedback prompts when using, which reduces the cognitive difficulty. This design gives consideration to daily assistance and safety protection, which makes the elderly feel more at ease when traveling alone and redefines the walker experience.

5.4 Users use Feedback Data to Verify

In order to evaluate the elderly users' satisfaction with the walker, 60 elderly users aged 65-85 with mild physical dysfunction were investigated in this study on the stability, labor saving, convenience of operation, psychological acceptance and scene adaptability of the walker. The scale is designed as follows(see Table 2):

Table 2. Statistical results of users' use of Likert scale (N=60)

Number	Scale Description	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
1	Anti-rollover ability of walker at rest or during pushing	1	2	3	4	5
2	Degree of upper limb burden during implementation	1	2	3	4	5
3	Complexity of operation such as mode switching and folding.	1	2	3	4	5
4	Self-esteem and independence experience when using walker	1	2	3	4	5
5	Adaptability of walker to different terrain indoors and outdoors	1	2	3	4	5

In this study, 60 elderly users of walking AIDS aged 65-85 (including some mild physical dysfunction) in a community were investigated through online and offline questionnaires, and 53 valid questionnaires were collected, and the data were sorted into Excel tables, with the feedback from the subjects and the survey items as columns(see Table 3).

Table 3. Summary of Expert Scoring Results

Serial number	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average score
1	4	4	4	3	3	3.6
2	3	4	3	4	3	3.4
3	4	3	2	4	4	3.4
4	3	5	4	2	2	3.2
5	3	4	5	3	4	3.8

The average score of each item is over 3 points, which shows that the content validity of the walker satisfaction scale is good and can comprehensively cover the measurement objectives. The data shows that the design performs well in product performance and user experience, which is superior to the traditional walker, and

initially achieves a harmonious relationship between people, products and environment. In the future, we will expand the sample size, do long-term durability tests, and optimize the operation force, appearance and man-machine interface of the switching mechanism according to the feedback, so as to enhance the competitiveness of the products and provide better travel assistance programs for the elderly and the rehabilitation population.

6 Conclusion

Based on the theory of wisdom and health care, this study developed a walker that can switch between two wheels and four wheels for the needs of the elderly at home. Through ergonomic design, the switching operation is more in line with the user's physiological and psychological characteristics, the structure is adapted to the home environment, and the function integration optimizes the experience. The design is stable, labor-saving, economical and practical, which ensures the safety of the elderly, reduces physical consumption and maintains their independent life and dignity. This study provides new ideas for the field of rehabilitation AIDS, promotes the individualized and scene-based development of products, and helps to improve the intelligent rehabilitation service system.

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