Optimization Strategies for the Design of Rehabilitation Aids for Parkinson's Patients based on Hierarchical Analysis

Huimin Wang[a] and Tianyang Zhu*[b]
Department of Art and Design Beijing University of Chemical Technology Beijing, China

Keywords: Parkinson's, Rehabilitation Assistive Devices, Hierarchical Analysis, Optimal Design.

Abstract: Objective: The Parkinson's disease has gradually increased in the elderly population in China, and the research of rehabilitation assistive devices for patients with Parkinson's has become more and more important. This study analyzes the existing Parkinson's rehabilitation assistive devices in the market, and proposes an optimization strategy for the design of rehabilitation assistive devices for Parkinson's patients according to the actual needs of patients. Methods: The existing research results of Parkinson's rehabilitation assistive devices were sorted out by inductive method, and the tendency of patients' needs between each level of rehabilitation products of assistive devices was extracted from functional level, service level and emotional level based on hierarchical analysis. Conclusion: At this stage, domestic research on the design of medical assistive devices for Parkinson's disease remains relatively scarce. The functions of the products are mostly limited to self-care or mobility assistance under the action of external forces; these products have problems such as insufficient targeting of functional positioning, lack of systemic and sustainability in the use process, and lack of emotionality. The optimized solutions and design strategies of inclusiveness and autonomy, systemic and sustainability, and emotional design are proposed to provide reference for future product design and application of training assistive devices for Parkinson's patients.

1 INTRODUCTION

Parkinson's syndrome (PD) is a neurodegenerative disease common in middle and old age (Liu 2016), and the number of Parkinson's patients in the world is about 6 million (Zhuang 2017). The increase in the number of Parkinson's patients and the weakening capacity of home-based patient care services have exacerbated the burden on family finances and social health care services. With the current scientific treatments, Parkinson's disease cannot be cured and can only be assisted by medication and physical rehabilitation training. It is an urgent problem to address in rehabilitation research on how to make patients less distressed and restore their ability to take care of themselves (Liu 2021). In the early stage of Parkinson's symptoms, the use of reasonable and scientific rehabilitation assistive devices is one of the effective methods to slow down the physical function lesions and improve the quality of life of patients. With the progression of Parkinson's disease, the tremor of movement and delayed gait impairment, as well as the psychological negativity lead to the gradual narrowing of the patient's range of activities, and the home becomes the patient's main place of activity. As patients spend more time at home, the need for physical exercise increases, which requires the optimal design of assistive devices in terms of autonomous exercise and emotional companionship to provide a more effective and comfortable home-based rehabilitation environment for Parkinson's patients, so as to realize the need for patients to complete autonomous exercise through assistive devices, which enhances the sense of self-efficacy and improves the sense of well-being.

[a] https://orcid.org/0000-0003-4398-8584
[b] https://orcid.org/0000-0001-5118-8216

Wang, H. and Zhu, T.
Optimization Strategies for the Design of Rehabilitation Aids for Parkinson's Patients based on Hierarchical Analysis.
DOI: 10.5220/0011206600003438
In *Proceedings of the 1st International Conference on Health Big Data and Intelligent Healthcare (ICHIH 2022)*, pages 25-36
ISBN: 978-989-758-596-8

2 OVERVIEW OF REHABILITATION ASSISTIVE DEVICES FOR PD

Parkinson's assistive devices are assistive devices that help patients overcome the obstacles of the disease, alleviate the adverse effects of symptoms such as tremor, bradykinesia and dyskinesia, and improve the ability to care for themselves in daily life. Through the use of medical assistive devices, Parkinson's patients can improve the completion of basic behavioral movements and effectively improve their quality of life while enhancing their ability to adapt to their environment. The improvement of self-care ability can promote the self-efficacy of Parkinson's patients, regulate negative psychological emotions, and alleviate the burden and stress of health care workers and family members.

2.1 Classification of Existing Parkinson's Rehabilitation Assistive Devices

In order to allow Parkinson's patients to spend their old age peacefully, elderly care with technology and assistive devices has gradually become the mainstream of social development (Li 2018) Research and analysis of existing Parkinson's assistive devices in the market can be categorized into whole-body assistive devices, upper limb assistive devices, and lower limb assistive devices based on their target limb parts, as shown in Table 1.

Whole-body assistive devices tend to act on the whole limb of the patient for rehabilitation treatment or data monitoring, and the main existing whole-body assistive devices are hyperbaric oxygen chamber, Parkinson's therapy device and physical data monitor, etc. (Mao 2020). The effect of cognitive training on exercise training in Parkinson's rehabilitation was investigated by Davide Ferrazzoli et al. It was found that cognitive training has a crucial role in motor training and sustained concentration is effective in accomplishing the target movement behaviors, and that hyperbaric chamber plays a role in improving cognitive impairment for Parkinson's patients (Davide 2018). Parkinson's therapeutic device is an innovative technology based on brain pacemakers and brain rehabilitation therapies that act on the patient's head, ears and feet to compensate for the lack of pharmacological and surgical treatment and improve tremor, rigidity and bradykinesia. The data monitor is applied to the patient's rehabilitation process to provide real-time data detection and feedback based on the patient's behavioral response, helping healthcare professionals to effectively monitor the patient's pathology and treatment effects.

Upper limb assistive devices are mainly applied to the patient's hand, and are used for patients with resting hand tremor to carry out rehabilitation training or assisted movement, and to improve the dexterity and completion of fetching movements, including finger training inserts, finger extension trainers, convenient fetchers and training gloves. The finger training board is equipped with wooden sticks of different diameters to guide patients to insert the sticks into the holes precisely, train the flexibility of finger joints and hand strength control ability, and improve hand and eye coordination function. The finger extension trainer includes grip strength ball, elastic finger sleeve and finger presser to help patients strengthen grip strength training and finger flexion and extension rehabilitation in the process of using the assistive device. The ergonomically designed gun-shaped convenient fetcher can help patients reduce tremor interference and provide convenience for patients to grasp various objects of different shapes and sizes, soft and hard.

The lower extremity aids mainly focus on the patient's legs, alleviating gait disorders caused by slow and rigid movement through intensive pace training, including laser crutches, walkers, exercise scooters, lower extremity gait exoskeletons and gait trainers. For plantar pressure correction, Liu Yan et al. started a ten-week training with the Lokomat lower limb robotic gait exercise system in forty Parkinson's patients, and the treatment confirmed that rehabilitation training with the lower limb robot had more significant effects than conventional rehabilitation training (Liu 2017). The BioMot, a lower extremity gait exoskeleton, can provide assistance to patients with gait rehabilitation and musculoskeletal injuries, and also allows for seamless interaction and safe movement to accommodate the user's intent and ability (Bacek 2017). The gait trainer can improve gait movements, limb coordination and muscle flexibility by training the patient's lower extremity muscles and nerve responses to achieve a balanced gait.

Table 1: Classification of Parkinson's rehabilitation assistive devices.

Targeted parts	Available products for assistive devices
Whole body	 Hyperbaric oxygen chamber  Parkinson's therapy device  Physical data monitor
Upper Extremity	 Finger training board  Finger extension trainer  Handy picker  Training gloves
Lower Extremity	 Laser crutch  Mobility aid  Gait trainer  Exercise scooter

2.2 Analysis of the Advantages and Disadvantages of Existing Parkinson's Assistive Devices

The current assistive devices for Parkinson's disease and their peripheral services are designed to have significant effects on patients' life assistance, medical care and functional exercise. In terms of life assistance, it is close to the patients' daily life, which can alleviate their impairment of clothing, food, housing, and transportation, improve their self-care ability, and improve the quality of life of Parkinson's patients. In terms of medical care, the product can effectively monitor the patient's health index and slow down the spread of the disease through medical means. In terms of functional training, patients are guided to use assistive device products for simple game interaction, physical exercise of local lesion areas, and enhancement of limb function. However, the existing design of Parkinson's assistive device in China remains in the exploration stage, and there are deficiencies in the detailed aspects.

The prevalence of Parkinson's disease in China is about 17%, with nearly more than 2 million Parkinson's patients (Mina 2019). The huge group base combined with the obvious differences in the degree of disease staging, onset site, significant symptoms, and changes in disease among patients, these problems lead to the difficulty of more refined functional positioning of Parkinson's assistive device products for different patients. According to the above analysis and comparison of existing assistive device products, it can be found that although the current assistive device has achieved a simple division for different parts of the patient's limbs. However, the assistive device for the whole body is only limited to the medical aspect and lacks the function training of the limbs. The assistive devices for upper and lower extremities only work on the common areas of the patient's body, such as the hands and legs, and lack attention to small areas of the body, such as the shoulders, small arms, knees, or feet.

Parkinson's disease is comprehensive, complex and long-term in nature. Existing assistive device products often only provide superficial and simple training for conditions such as hand tremor and short gait. If the patient's tremor amplitude deepens or decreases during use, or if other parts of the body other than the hands and legs are added, the single function cannot meet the complex disease situation

in real time, and it is difficult to achieve in-depth and lasting support for the patient's condition and variations. The existing Parkinson's assistive devices have certain defects in terms of volume structure and emotional care, in addition to basic functions. Most medical care assistive devices such as hyperbaric chamber, Parkinson's therapy device, gait trainer, etc. are large and expensive, and their use is limited to exclusive places such as hospitals and nursing homes. Considering the individual differences in patients' different status backgrounds, home living environments and economic bases, many high-end assistive device products are difficult to access. The limitations of the existing Parkinson's assistive devices in terms of targeted features, use sites, system services and emotional care are all pressing issues that need to be addressed in future designs.

3 NEEDS ANALYSIS OF PARKINSON'S PATIENTS

3.1 Motion Extraction for Parkinson's Patients

Standardized management of Parkinson's disease includes standardized clinical diagnosis, disease severity scores, and treatment decisions. Some standardized assessment systems such as the Unified Parkinson's Disease Rating Scale (UPDRS) score and Hoehn and Yahr (HY) staging provide good support for the docking of the Parkinson's rehabilitation assistive devices (Tan 2019). Parkinson's disease is currently classified by the Hoehn and Yahr (HY) staging, which is medically accepted. HY staging is divided into five stages, where staging <3 is defined as early Parkinson's disease, staging at 3-4 is defined as mid- to late-stage Parkinson's disease, and staging at 5 is defined as late-stage Parkinson's disease (Wang 2017). In the early and middle stages of Parkinson's, the use of assistive devices can be effective in improving patients' self-care ability and quality of life, and the design of interventions should be considered for the disease and actual needs of patients at this stage. Based on the Unified Parkinson's Disease Rating Scale (UPDRS version 3.0), the distribution of muscle pain in Parkinson's patients in Figure 1 shows that the main lesions are in the back, arms and hands of the upper extremities, and the leg muscles of the lower extremities, where the assistive device can be used for targeted rehabilitation.

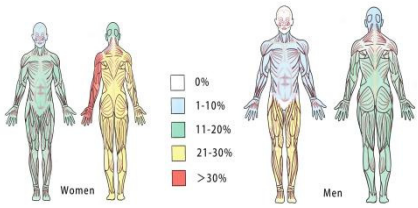

Figure 1: Distribution of muscle pain sites with Parkinson's patients.

The assessment of the activities of daily living and mobility check of the scale takes into account the impact of changes in the onset and degree of resting tremor and muscle tonus on patients' daily behavioral movements. Combined with the analysis of the symptom performance of patients in the early and middle stages of PD, the key behavioral actions of patients were extracted to set the reference of assistive device actions and to make design guidance for the corresponding functional services of the Parkinson's rehabilitation assistive device, as shown in Table 2.

Table 2: Correlation analysis based on stage symptoms of Parkinson's disease and the needs of the patients.

Staging	Symptoms	Mobility Summary	Demands for assistive devices
Stage 1	Tremor with unilateral limb, myotonia or bradykinesia without significant functional impairment or with mild impairment.	Basic fluency in daily activities.	There is no need for assistive device intervention.
Stage 2	Resting tremor, myotonia or bradykinesia extending to both limbs.	Patients can still maintain normal posture with mild impact on daily life.	Assistive device needs exist for basic actions in daily life, and the efficiency of actions is improved to some extent by assistive device.

Stage 3	Presence of some degree of limitation of mobility with mild or moderate functional impairment.	There is some impairment in activities such as getting up, dressing, walking, tying shoelaces, and writing. However, the patient can live independently without relying on others.	The need for assistive device is high for daily life, and the improvement effect is more obvious by using assistive devices.
Stage 4	People with more severe tremor, myotonia, bradykinesia, and dyskinesia have difficulty taking care of themselves and require caregiver assistance for some behaviors	The impairment in activities such as getting up, dressing, walking, tying shoelaces, writing, etc. is relatively severe, and the patient can still manage to stand or walk without support.	The need for assistive devices is high, and the functions and services need to be enhanced for mobility assistance, medical care, and emotional care for co-occurring psychological problems.
Stage 5	The symptoms of the disease are so severe that they cannot take care of themselves and require a caregiver to accompany them throughout their lives.	Unable to stand and confined to bed or wheelchair without assistance.	Patients have difficulty operating the assistive device on their own and have limited needs.

3.2 User Role Establishment and Its Requirements

In the context of social medical technology development and family economic conditions improvement, more families with Parkinson's disease are beginning to value the use of assistive medical products, and can afford more to improve self-efficacy and quality of life for their patients and enhance their sense of well-being. Most Parkinson's patients tend to be senior citizens, with an average age of onset of about 60 years old. The material and spiritual life needs of elderly Parkinson's patients are characterized by their age, diversity, differences, emotions and stages (Huang 2020). Therefore, the above characteristics put forward new requirements for the design of paramedical products, and the functional focus of the study was extended from a single improvement in quality of life to helping patients to exercise themselves to alleviate the progression of the disease, with a more advanced goal of achieving patient self-efficacy. In this study, we selected elderly Parkinson's patients aged 60-75 years old as the target users, collected the impact of patients' different symptoms on their daily actions through Kano questionnaire, and summarized the functional requirements of Parkinson's assistive devices in order to optimize the experience of using them, enhance their physical functions and improve their quality of life. The purpose of the study is to optimize the experience of using the assistive device, enhance the physical function of patients and improve the quality of life. Through the basic research of Parkinson's patients, the user representatives were selected to make a typical target user portrait, see Figure 2.

Figure 2: Typical target user profile

A list of 18 basic functional needs of Parkinson's patients for assistive devices based on their motor behaviors such as tremor, bradykinesia or dyskinesia, and psychological behavioral characteristics such as depression, anxiety and dependence, combined with action extraction of symptom performance and typical target user portrait analysis. Among them, the material life perspective includes the basic ability needs of patients in daily life; the rehabilitation medical perspective includes the needs of patients' physical function status and mental health; the mental-emotional perspective includes patients' own emotional development and the overall communication with family and society. Through the information feedback from the Kano questionnaire, the scatter diagram of basic functional needs of Parkinson's rehabilitation assistive devices was drawn according to the priority level of the 18 functional needs of the patients under investigation, which were classified as charismatic needs, expectation needs, undifferentiated needs and essential needs, as shown in Figure 3

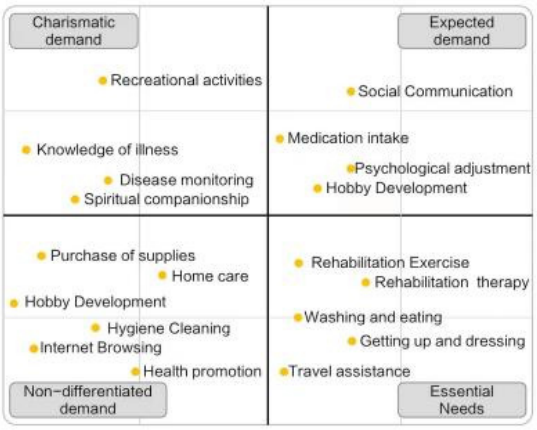

Figure 3: Scatter diagram of basic functional needs for Parkinson's rehabilitation assistive devices.

Through the user feedback of Parkinson's assistive device on the Internet, 18 basic functional requirements were sorted and summarized based on three levels: physical life, medical rehabilitation, and spiritual and emotional life, as shown in Figure 4.

Combined with the data from the research questionnaire, the functional demand points of Parkinson's assistive devices that appear more frequently in the user experience and expectation feedback were summarized.

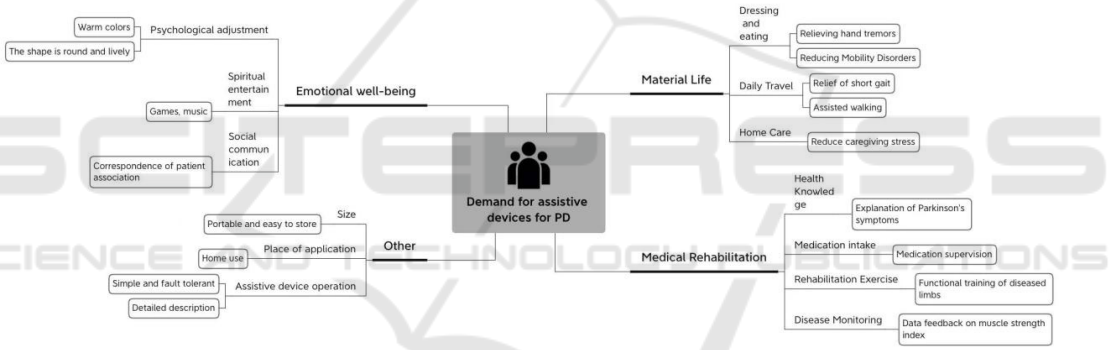

Figure 4: Summary of functional requirement points for Parkinson's assistive devices

4 HIERARCHICAL ANALYSIS OF FUNCTIONAL ELEMENTS OF PARKINSON 'S ASSISTIVE DEVICES

4.1 Functional Element Hierarchy

Analytic Hierarchy Process (AHP) refers to the hierarchy of complex decision-making systems, transforming multi-element decisions into multi-level single-element problems, and helping to analyze the weights or priorities among the elements at different levels (Wang 2021). To address the issue of the basic functions of rehabilitation assistive devices for Parkinson's patients, it is necessary to analyze the structural appearance, operational processes, functional services, emotional care and other design elements of rehabilitation assistive devices, taking into account the different identity backgrounds, generational relationships, life socialization, goal preferences, behavioral habits and health status of patients and other relevant factors. The demand for rehabilitation assistive device use by Parkinson's patients is diversified and differentiated, and there is no obvious demand hierarchy and structural division of demand direction yet, so it is suitable to use hierarchical analysis to summarize and analyze the interrelationship and importance degree among different elements.

According to the complex basic need points of Parkinson's patients, it can be seen that the patients have high needs for basic life at home in terms of

clothing, food, transportation, medical rehabilitation effects of the disease and emotional spiritual companionship. To meet these needs, the functional design of assistive devices should focus on whether the structure of the product is lightweight, convenient, easy to operate, and suitable for patients with mobility impairments to use at home. The design of assistive devices should also consider whether the services can meet the needs of patients to establish contact with their families and healthcare professionals, whether the efficacy of the devices can meet the needs of patients to improve their self-care ability and medical rehabilitation, and whether they can provide emotional care to patients' psychological, emotional and attitudinal preferences. Following a generalization of the above needs analysis, five basic requirements for Parkinson's assistive devices to meet the needs were derived: appearance structure, operation process, service level, functional effectiveness, and emotional care, which constitutes the hierarchical analysis model shown in Figure 5.

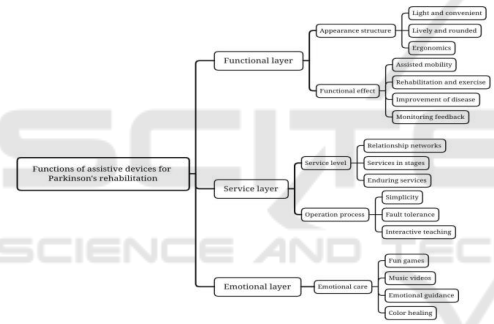

Figure 5: Analysis of functional elements of Parkinson's rehabilitation assistive devices.

The functional aspects include the basic functions that an assistive device should have for Parkinson's rehabilitation. According to user analysis and research, for patients suffering from resting tremor, myotonia and dyskinesia or bradykinesia, their basic needs for assistive devices should include the ability to improve their mobility skills in daily life, such as dressing, dining, cleaning, walking, etc., and to improve their self-care ability. The assistive device can be used for simple movement training and scientific medical interventions to improve physical functions, monitor the feedback of the disease and alleviate the extent of the disease to a certain extent. The design of Parkinson's assistive devices should include diverse functional designs for patients with different differences, combining elements such as the user's background, physical health condition and the environment in which the product is used, to meet the patient's needs for self-care and medical rehabilitation in daily life.

The service dimension mainly refers to the service design of the Parkinson's rehabilitation assistive devices. The service of the rehabilitation assistive devices not only includes the service for the patients themselves, but also needs to consider the connection between the patients' families, communities and medical care, and build a multi-point and related service system. For the patients themselves, the services of rehabilitation assistive device products cannot be limited to a certain stage and a certain problem. The long onset cycle of Parkinson's disease requires that assistive device products should extend the time span of services, deepen the patients' memory of using them, and strengthen the service effect and user experience. For the patient's peripheral relationships, it is necessary to strengthen the connectivity between each relationship for integrated services.

The Parkinson's rehabilitation assistive device should be a more "people-oriented" product, and the product design should incorporate emotional care for patients. Parkinson's disease is a common degenerative disease of the nervous system, caused by lesions in certain functional areas of the brain. If the lesions in these areas involve functional areas that control mood and emotion, it will affect the patient's psychological mood, and its nonmotor symptoms are mainly manifested in psychological behavior as depression, anxiety and dependence. Patients with PD suffer from the disease and are often in a closed environment due to limited mobility and lack of communication with the outside world, and are prone to persistent depression, difficulty concentrating, lack of interest in life and work, and other depressive moods. The confusion and uncertainty about the future and the dependence on medical staff and family members due to the inability to take care of themselves are emotional factors that need to be considered and taken care of in the design of the Parkinson's rehabilitation assistive device. The design of rehabilitation assistive devices can enhance the emotional care of patients in terms of needs such as fun games, music videos, emotional de-escalation and color healing.

4.2 Integration of Functional Elements

From the summary of the demand points of Parkinson's patients, it can be concluded that the main expectation of users for assistive devices is to effectively alleviate the degree of their own lesions, reduce the impact of symptoms such as limb tremors

and muscle stiffness on behavioral movements, improve movement flexibility, and restore normal body posture. Therefore, functional rehabilitation training is the primary function, and the peripheral design can be enriched on this basis. In addition, the target users of assistive devices should target the elderly Parkinson's group and its surrounding relationship network, and systematic services between patients and their families, communities and medical care should be established. Considering that the place of use of the product is suitable for home use, the product can be designed to be more convenient for carrying and storage. In recent years, wearable devices are widely used in the medical field and have an important role in health monitoring, efficacy measurement, and disease discovery, etc. Applying them to the medical field has become a hot topic for medical device innovation, and the products are gradually applied to clinical practice (Hu 2018).

At present, there are few independently developed wearable device products in China, and they are generally bulky and heavy and not easy to wear (Chen 2017). However, this could contribute to the design of assistive devices for Parkinson's rehabilitation, and the design of assistive devices as wearable is considered from the perspective of usage, and the structure of more lightweight and handy wearable assistive devices is studied. In view of the psychological and emotional characteristics of patients, the functions and services should also be integrated into the corresponding emotional care. The basic needs of Parkinson's patients for the rehabilitation assistive devices and the functional elements that the assistive devices should have are clarified through the preliminary research, based on which the logical relationship between the two is further combined, the integration of functional elements shown in Figure 6 is carried out to find the inner connection between patients' needs and the functional embodiment of the assistive devices, so as to guide the optimal design of the product.

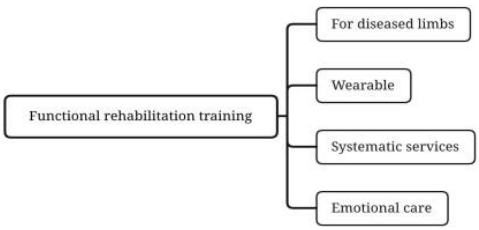

Figure 6: Integration of functional elements of Parkinson's assistive devices.

5 OPTIMIZATION STRATEGY FOR ASSISTIVE DEVICE DESIGN FOR PARKINSON 'S REHABILITATION

The design of assistive devices for Parkinson's rehabilitation requires comprehensive consideration of the product's structural appearance, functional services, and user experience. Combining the above research and analysis results, the design of assistive devices for Parkinson's rehabilitation can be optimized at three levels: functional, service, and emotional. At the functional level, assistive devices for Parkinson's rehabilitation should be designed to meet the basic needs of users for self-care, taking into account the differences in the specific parts of the patient's body and the degree of the disease. At the service level, assistive devices for PD should pay more attention to the systematic connection between patients and their families, medical and nursing staff and social relationships, and meet the actual changing needs of patients with a comprehensive developmental perspective, and be able to provide sustainable assistance as the patients' own conditions change. At the emotional aspect, assistive device products should include emotional design to give users respect and care, so that they can feel warmth and companionship during their use experience.

5.1 Implanting Diverse Linkage Design

The functional dimension of assistive devices for Parkinson's rehabilitation considers the concept of inclusion in functional design. Inclusive design means that designers, product manufacturers, and suppliers ensure that their products and services meet the needs of the widest possible audience, regardless of age, their own abilities, or special circumstances, so that more people have equal access to the products. Based on the concept of inclusive design, the design of training assistive devices for Parkinson's patients should take more into account the diverse needs of different patients, fully consider the individual differences of the audience, and make targeted designs for the functions, services and use environment of the products. The rehabilitation pressure and psychological conditions of Parkinson's patients require that the design of assistive devices should avoid labels such as "sick", "disabled" and "disable".

It is important to put aside narrow assumptions about patients, to maintain and respect the self-esteem of the audience as much as possible, to

enable patients with different degrees of illness to feel the corresponding reasonable care, and to meet the specific needs of patients rather than deepen the psychological burden of rehabilitation. Patients with PD have different needs based on their background, family environment, health care services and economic level. Therefore, it is necessary to conduct a comprehensive research on the users, to make a reasonable and accurate positioning of the product according to the actual needs, and to meet the personalized training assistive device needs of the patients. The focus of the design of assistive devices for Parkinson's patients can be shifted from large and expensive specialized medical assistive devices to compact and universal home portable training assistive devices with more diverse functions to strengthen the wide applicability of the products.

Parkinson's patients have reduced independent living ability due to resting tremor, bradykinesia and dyskinesia, and many of them need personal accompaniment to dress and eat, wash and clean, and even travel. The design of assistive devices for these patients should take into account the patients' behavioral needs, be in line with ergonomics, and be more suitable for the patients' diseased limbs in terms of structure and function. The wearable rehabilitative assistive devices are lightweight and portable, and more flexible in terms of place and mode of use. This paper proposes a conceptual drawing and design reference of the product, which can be used for targeted rehabilitation training from the past single non-linkage product to multi-point linkage design for different lesion sites and degrees of lesions of patients.

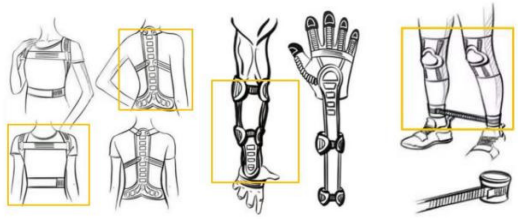

Figure 7: Concept diagram of wearable rehabilitation assistive device for PD.

As shown in Figure 7, the design of wearable elastic back belt is adopted for the patient's low back, which is combined with the exoskeleton to strengthen the support effect and correct the patient's flexion posture. For the upper limb area, a spring glove design is adopted to strengthen the resistance of the small arm and hand muscles. For the lower limbs, the acupuncture point electrotherapy knee brace and pace standardizer are designed to stimulate the muscle strength of the lower limbs and give the patient standardized pace parameters to relieve short gait through stride training. Compared with high-end medical devices, the operation process setting of assistive devices should be more simplified to improve the fault tolerance and meet the needs that patients can achieve independent training as users. Through scientific and effective training, the patient can improve the completion of basic movements required for life, strengthen his or her self-care ability, and thus obtain a higher sense of self-efficacy, while reducing the burden of care on the family and health care personnel.

5.2 Establishing a Systematic Service Network

The service aspect for designing assistive devices for Parkinson's rehabilitation should place more emphasis on systemic and sustainability to improve the service quality of the product. Systematic design requires that the users of the product are not only the users themselves, but also the surrounding relationships of the users, and establishes a systematic connection for the user groups involved in the use and service process of the whole product. The service design of assistive devices for Parkinson's training can integrate the functional characteristics of smart home and the background of the era of smart IOT to build a service system for patients and families, communities and hospitals to care for the rehabilitation process of Parkinson's patients to provide systematic services and improve the overall environment for the use of assistive devices. A cell phone APP can be designed for the training assistive devices, see Figure 8.

The app can provide sub-functions such as assistive device operation, data feedback, interactive training and communication community. Users can use the rehabilitation assistive device app to learn how to use the device, learn how to wear it, and learn how to use it. The user's account is linked to family members, doctors and caregivers, and the patient's use of the assistive device is uploaded to the network in real time. The feedback on the changes in physical data generated by the use of the assistive device helps medical and family members to better grasp the actual situation of the patient and take corresponding medical and caregiving measures. The interactive training in the app can improve patients' training enthusiasm and participation through a game-like approach, and help patients improve their physical functions in the training process. The communication community can set up patient associations and physician consultation to

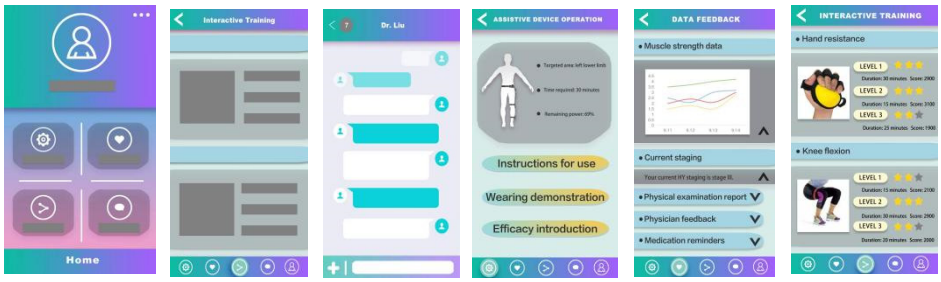

Figure 8: User-side interface design of assistive device APP for Parkinson's rehabilitation.

strengthen the systematic connection between users and build a diversified service chain.

The concept of sustainability is applied to the design of assisttive devices for Parkinson's training, which is reflected in the product's functional service focusing on the overall long-term process of the patient's condition. The Parkinson's syndrome is an irreversible degenerative disease that cannot be cured by the current level of medical research. The assistive devices can be designed to intervene in the degenerative process of the patient's physical function, and the products cover different degrees of degenerative corresponding training functions to meet the user's continuous auxiliary training needs. For patients with early stage PD, training assistive devices can provide simple limb exercises for unilateral limbs with mild symptoms, improve muscle flexibility, reduce resting tremor, and delay muscle stiffness and tonicity. For patients with middle and advanced Parkinson's disease, we can provide comprehensive functional training and assisted living services to improve patients' ability to take care of themselves and their quality of life on the basis of continuous muscle exercise. The service process will be sustainable and the service life of the assistive device will be extended.

5.3 Deepen the Emotional User Experience

The special psychological attitude of Parkinson's patients determines that the design of the relevant training assistive devices should pay attention to the user's reflective emotions during the usage, taking into account the patient's expectation of respect, the desire for disease relief, the need for companionship and emotional relief and other instinctive needs. This instinctive layer of emotion transcends the logical judgment of thinking and it is reflected in the appearance of the assistive device product, which can attract the patient's attention from the shape and color matching in the first place, thus creating the impulse to understand and use. Excellent design on instinctive level emotion can reasonably avoid the rejection of assistive device products by some patients with low self-esteem and bigotry.

Training assistive device products for PD need to consider avoiding the label of "aging", reducing the use of cold metal and minimalist industrial style in the design, and adopting more rounded and youthful design to reduce the emotional stimulation and psychological pressure of patients for rehabilitation training and improve the acceptance of the product. In order to alleviate patients' negative psychology such as depressed mood and anxiety and depression, the choice of color of assistive devices can be combined with the medical concept of color healing therapy. Scientific studies have shown that warm colors, such as yellow and orange, can alleviate depression and pessimism, while cool colors, such as blue and green, can soothe boredom and anxiety. Exposing Parkinson's patients to a scientific color palette in the color selection of assistive devices can effectively alleviate the psycho-emotional symptoms of non-motor disorders in Parkinson's patients.

The color matching design of the Parkinson's rehabilitation assistive device was based on the color healing method. As shown in Figure 9, for patients whose psycho-emotional expression of non-motor symptoms is low and pessimistic, warm colors are considered as the main color scheme, retaining 20% of the gray degree joint connection as well as 20% of the cold color decoration reflecting the technological sense of the product and enhancing the conviction of the medical product. For patients whose psychological mood manifests as boredom and anxiety, color matching makes cold and warm contrasts, and on the basis of soothing boredom through cold colors, warm color decorations are used to alleviate the excessive mechanization caused by cold tones bringing psychological pressure to patients.

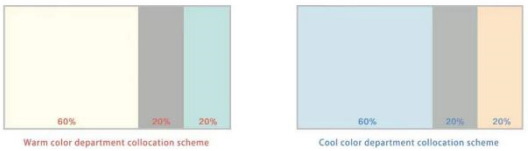

Figure 9: Color matching scheme of assistive devices for Parkinson's rehabilitation.

Further behaviors are guided by instinctive emotions. The behavioral level of training of the assistive device is designed to correlate with the patient's experience of using the assistive device. The level of behavior that governs daily behavior and brain activity is reflected by the experience of using the assistive device. The design for the patient's behavioral level should take into account the efficiency and enjoyment of using the training assistive device product. Due to the aging of the patient group with Parkinson's disease and the special characteristics of action behavior and mental behavior, the functional design requires the operation process of assistive device to be simple and easy to understand, with a simple and clear command interface and a certain degree of fault tolerance, so that patients can quickly accumulate operating experience and enhance the efficiency of using the product. Games are not only an aid to conventional rehabilitation, but also an alternative therapy(Meijer 2017). In the overall use process of the product, human-computer interaction can be enhanced through simple games, such as setting levels and sending simple instructions to guide patients to complete the corresponding training, and matching encouraging points and reward exchange mechanisms. Game-like behavioral design facilitates the user to have fun and regulate their emotions while increasing their motivation to use the device.

Through the optimal design of instinctive and behavioral aspects, we can enhance the meaningful value of the product and realize the emotionality of the reflective aspect. Training assistive devices for Parkinson's patients should fully understand the users' own psychological aspirations and meet their diverse emotional needs. Adhering to the people-oriented principle and creating a design that truly impresses people can increase patients' satisfaction with the use, establish a two-way connection and emotional bond between the user and the product, establish the centrality of this training assistive device product, and deepen patients' awareness and loyalty to the training assistive device product.

6 CONCLUSIONS

The increasing prevalence of Parkinson's disease and the diverse treatment needs of a large group of patients have raised higher requirements for the corresponding training assistive devices. The optimal design of training assistive devices for Parkinson's patients should be based on a thorough research of the patient population and a comprehensive understanding of the patient's background, degree of disease, behavior, family environment, social relationships, and the medical treatment received. It should meet the actual needs of the users and establish a multifaceted connection of "patient-family-community-medical care" to form an integrated product service system. It should analyze the strengths and weaknesses of various assistive device products in the market, such as life support, medical care, and functional exercise, and propose corresponding optimization solutions. The future design of Parkinson's training assistive devices should pay more attention to the inclusiveness and autonomy of the products, so that each patient can use the training assistive device equally and with dignity, and enhance the user's self-care ability. The process of using the product should place more emphasis on the systemic nature of the service and the sustainability of the use of long-term effects. The systemic service should strengthen multiple connections and enhance the patient's self-efficacy through long-term accompanying treatment. The design also needs to integrate the emotional care for patients, adhere to the "people-oriented" emotional design. The social background of PD determines that the training assistive devices for the patient group have a broad market development prospect, and we should actively promote the innovative design of training assistive devices for PD to provide better services for more people with the disease, increase the sense of well-being, and relieve the pressure and burden of the patient's family and social health care.

REFERENCES

Bacek T,Moltedo M,Langlois K,et al. (2017). BioMot exoskeleton-Towards a smart wearable robot for symbiotic human-robot interaction. C. //International Conference on Rehabilitation Robotics.IEEE Int Conf Rehabil Robot. 1666.

Chen X.B.,Liu L.R.,An Zheng,et al. (2017). Analysis of the current situation of clinical application of wearable

exoskeleton rehabilitation assistive device .J. Science and Technology Herald. 35(2), 50-54.

Davide Ferrazzoli,Paola Ortelli,Graziella Madeo,Nir Giladi,Giselle M. Petzinger,Giuseppe Frazzitta. (2018). Basal ganglia and beyond: The interplay between motor and cognitive aspects in Parkinson's disease rehabilitation. J. Neuroscience and Biobehavioral Reviews.90.

Hu Kehui,Chen Zhenyun,Zhang Shuxin,Feng Li,Song Yang Yang,Huang Wanru,Pei Zhigang. (2018). Research and application of wearable devices in rehabilitation medicine in developed countries. J. China Digital Medicine.13(08),56-59+15.

Huang Qun,Huang Juan. (2020). Study on the optimal design of assistive device for senior citizens in home care model. J. Design Art Research. 10(03), 71-75.

Li F, Liu Q, Li J. (2018). Design of assistive device for geriatric rehabilitation based on morphological experience. J. Packaging Engineering. 39(20), 152-158.

Liu QH,He J,Wang M. (2021). Effect of rehabilitation exercise training on limb function and self-care ability of Parkinson's disease patients. J. Qilu Nursing Journal. 27(11), 150-152.

Liu S.Y., Chen B. (2016). Current status of Parkinson's disease prevalence. J. Chinese Journal of Modern Neurological Diseases. 16 (02), 98-101.

Liu YP,Chen MY. (2017). Study on the efficacy of Lokomat lower limb rehabilitation robot on improving walking ability of patients with Parkinson's disease. J. China Rehabilitation. 32(1), 30-32.

Mao B,Li Y,Yang Yang. (2020). A review of Parkinson's rehabilitation assistive device design. J. Packaging Engineering. 41(08), 23-29.

Meijer HA,Graafland M,Goslings JC,et al. (2017). Systematic review on the effect of serious games and wearable technology used in rehabilitation of patients with traumatic bone and soft tissue injuries. J. Arch Phys Med Rehabil.

Mina Chen. (2019). The design and application of Parkinson's "mask face" passive massage rehabilitation exercise. D. Hangzhou Normal University.

Tan Y, Hao HL, Li YF. (2019). Current development of wearable devices in the chronic disease management of Parkinson's disease. J. Chinese Journal of Neuroimmunology and Neurology. 26(01), 52-55.

Wang Luyao,Zhou Yuhui,Li Yongchun. (2021).Research on museum cultural and creative design based on hierarchical analysis. J/OL. Packaging Engineering.1-10.

Wang Y, Pan H, Jian F, Chen N, Zhang L, Yang SH. (2017). Analysis of tremor characteristics in patients with different clinical stages of Parkinson's disease. J. Chinese Journal of Neuroimmunology and Neurology. 24(01),25-28.

Zhuang Yuan. (2017). Design study of assistive device for Parkinson's patients' self-care class under universal design vision. D. Wuhan University of Technology.