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Telerehabilitation system construction: design of a comprehensive rehabilitation training assessment software

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Abstract: *During the COVID-19 pandemic, people in lockdown areas are unable to go to hospitals or rehabilitation institutions for face-to-face rehabilitation treatment, which also brings more inconvenience to people in remote and developing countries. The telerehabilitation is a good solution. As the core of rehabilitation treatment, the degree of informationization of the rehabilitation assessment directly determines the efficiency of telerehabilitation treatment. This paper proposes a telerehabilitation assessment software based on the C/S architecture, which can complete six different rehabilitation assessment schemes (including Manual Muscle Test, Berg Balance Scale, Barthel Index, Functional Independent Measure, Boston Diagnostic Aphasia Examination and Hamilton Depression Scale) to further develop patient-centred and home-based telerehabilitation programmes.*

Keywords: *Home-based telerehabilitation, Rehabilitation Assessment, Software design, C/S*

1. Introduction

More than 1 billion persons in the world have some form of disability. This corresponds to about 15% of the world's population [1]. With the help of rehabilitation training, it is possible to improve people with disability physical function, reduce the need for regular health services and long-term care, and enable people with disability to have an independent life. Especially for people with physical impairments, active and effective rehabilitation within the first 3 months after stabilisation can significantly improve the eventual recovery of motor function and significantly reduce the likelihood of permanent disability[2].

Nonetheless,the outbreak of COVID-19 in December 2019 quickly developed into a global pandemic, COVID-19 can cause a wide range of problems that affect several organ systems, resulting in long-term rehabilitation needs[3, 4]. For people in lockdown areas, the lack of access to hospitals or rehabilitation facilities for face-to-face rehabilitation causes major problems in their lives. At the same time, the majority of people with disabilities live in relatively remote areas and developing countries, with 80% living in rural areas, where they have various barriers to mobility and low economic incomes [5]. This contradiction significantly increases the cost of accessing rehabilitation services for people with disabilities, and it is often the case that travel costs exceed the cost of medical treatment or that medical treatment is abandoned due to travel difficulties.

Due to the constraints of technology, the traditional model of diagnosis and treatment between a physician and a patient in person has existed for thousands of years. Since the late 20th century, research and applications in areas such as telemedicine and telerehabilitation, including but not limited to cancer, cardiovascular disease, stroke and musculoskeletal disorders, have been undertaken to break away from the traditional medical model, with some initial results[6]. Edgren et al. concluded from a randomised controlled trial that starting a home-based telerehabilitation programme within 4 months after a hip fracture would be potentially be as beneficial as an inpatient rehabilitation programme[7]. It has been indicated that telerehabilitation approaches can be as efficacious as conventional rehabilitation in improving activities of daily living (ADL). It enhanced the compliance of rehabilitation training. For stroke patients with hemiplegia, home-based telerehabilitation compared to conventional rehabilitation

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significantly improves some motor function tests [8, 9]. Fanget's study showed that after 3 weeks of telerehabilitation intervention, it was effective in improving the cardiorespiratory function of coronary patients. Telerehabilitation, an innovative approach to healthcare delivery, appears to be a viable, safe and effective solution [10].

The telerehabilitation is the rehabilitation medical services across regions based on the integrated use of communication technology, remote sensing technology, remote control technology, computer technology and information processing technology [11]. Telerehabilitation is a product of combining rehabilitation medicine with computer technology, sensor technology and information processing technology. Telerehabilitation involves most areas of rehabilitation engineering, including rehabilitation assessment, rehabilitation treatment, rehabilitation training, and rehabilitation information management. On the one hand, it can improve many of the shortcomings of the traditional rehabilitation model, and can address the unbalanced and unreasonable distribution of rehabilitation resources in different regions, further optimising rehabilitation resources. On the other hand, it is a new rehabilitation resource that embodies a new rehabilitation concept. It can help rehabilitation specialists to carry out rehabilitation services and improve their working capacity and efficiency [10, 12].

Rehabilitation assessment is an important fundamental part of telerehabilitation and its correctness directly affects the effectiveness of rehabilitation. By collecting and analysing patient data, the assessment can accurately determine the degree of impairment and provide an objective basis for the correct diagnosis of the disease [3, 13]. In order to digitally store and statistically analyse the results of the rehabilitation assessment and solve the tediousness of manual recording in the rehabilitation assessment, we have developed a comprehensive rehabilitation training assessment software that can assess patients on six items: the Manual Muscle Test, the Berg Balance Scale, the Barthel Index, the Functional Independent Measure, the Boston Diagnostic Aphasia Examination and the Hamilton Depression Scale. The architecture of this system is shown in Figure 1. The system enables the standardisation of telerehabilitation and the integration of the rehabilitation treatment process, and it has certain significance in the teaching, research and clinical work of rehabilitation medicine.

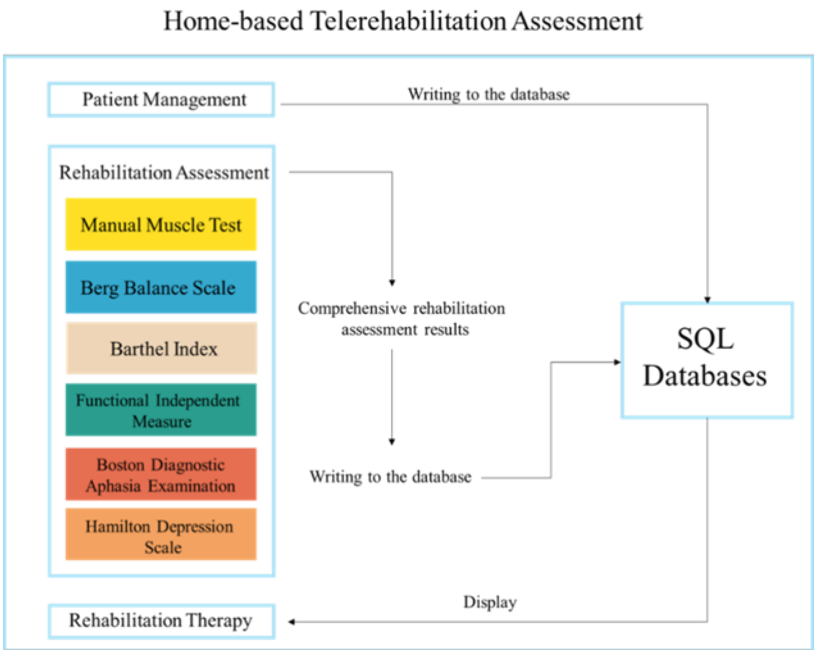

Figure 1: Home-based Telerehabilitation Assessment.

2. Functional design of the rehabilitation assessment software

2.1. Design of the main interface

The system adopts a architecture based on the C/S (Client/Server) model, with a cross-platform and large-scale database Microsoft SQL Server 2000 as the database. C/S model is a distributed model in a network environment, and is more suitable for real-time processing of the database and large amount of data. B/S (Brower/Server) is oriented towards an unknown user group and has relatively weak control

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over security, while C/S is generally oriented towards a relatively fixed user group and has strong control over information security. The system built in C/S mode can optimize the use of network resources and has better portability and maintainability, and because the system is relatively closed, the security and confidentiality performance of the system is also higher, so the system adopts the C/S model [14].

Entered your username and password correctly, and click “Login”. The main interface appears to reveal the platform interface, which displays information on Patient Management, rehabilitation assessment and rehabilitation treatment, as shown in Figure 2:

Figure 2: Main interface.

By clicking on Patient Management on the top of the interface, the user enters the corresponding interface, which shows the patient's historical rehabilitation assessment results. The data from the assessment process is recorded in the Patient management system. In addition, the system can also query and compare the results of the patient's previous rehabilitation assessments and observe the patient's treatment results. The Patient management interface is shown in the Figure 3:

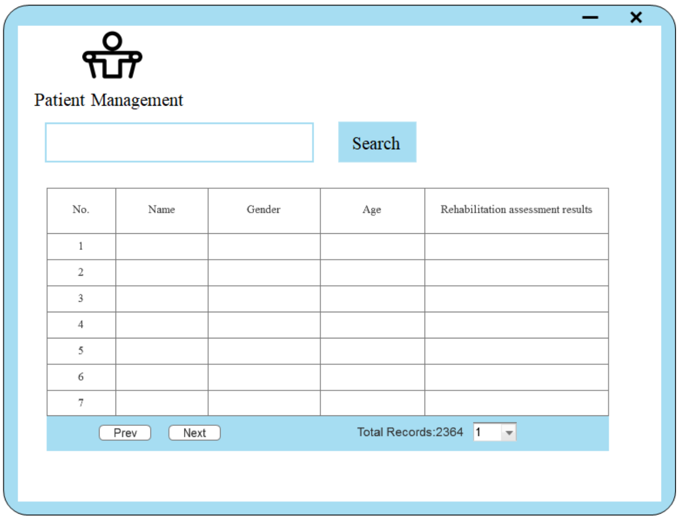

Figure 3: Patient management interface.

By clicking on the rehabilitation assessment in the interface, the user can enter the corresponding interface. At present, the user can choose from six rehabilitation assessments, namely Manual Muscle Test, Berg Balance Scale, Barthel Index, Function Independent Measure, Boston Diagnostic Aphasia Examination and Hamilton Depression Scale. After the rehabilitation assessment is completed, the system automatically integrates the results of each assessment item and outputs a comprehensive diagnosis and assessment report with one click. In the Patient management interface, the user can view the history of reports. The system also automatically extracts targeted treatment plans from the database based on the diagnostic results of the rehabilitation assessment, and has a print function so that the rehabilitation practitioner can refer to the treatment plans and carry out rehabilitation training for the patient.

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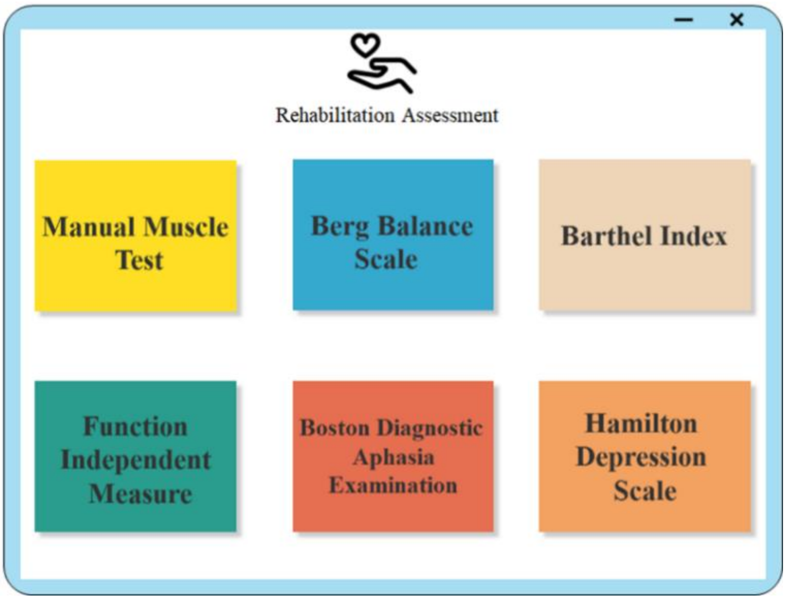

Figure 4: Rehabilitation Assessment.

2.2. Design of the Rehabilitation assessment interface

2.2.1. Manual Muscle Test(MMT)

Muscle strength assessment is one of the most fundamental elements in the diagnosis and rehabilitation of musculoskeletal disorders. The most commonly used method for measuring muscle strength is the manual muscle test. Depending on the function of the different muscle groups, the patient completes certain movements under weight loss, gravity and resistance conditions. It is classified into 0-5 levels according to the range of motion and resistance to gravity. MMT is simple and easy to use and is widely used in clinical practice. There is evidence for good reliability and validity in the use of MMT for patients with neuromusculoskeletal dysfunction[15]. The muscle strength assessment is used to determine the degree of muscle weakness and to evaluate the effect of muscle strengthening training. The interface of the Manual Muscle Test implemented in this system is shown in Figure 5.

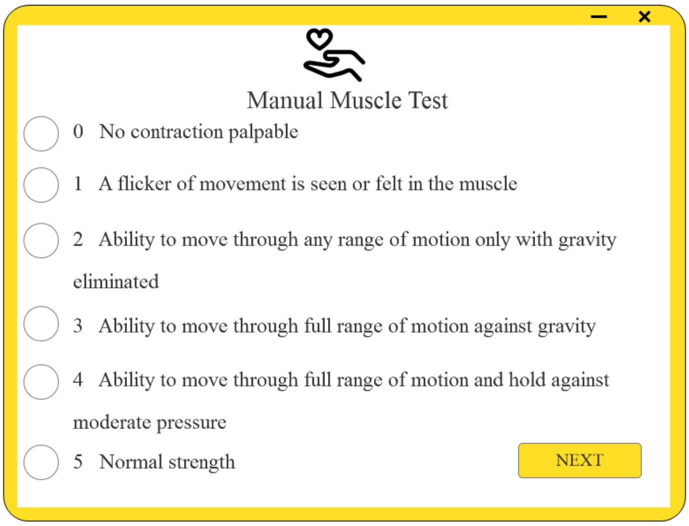

Figure 5: Manual Muscle Test interface.

2.2.2. Berg Balance Scale(BBS)

The Berg Balance Scale(BBS) is a comprehensive scale for the assessment of body balance function developed by Katherine Berg [16] through interviews with health professionals and patients. It explores various methods to assess balance, and the interface of the Berg Balance Scale is shown in Figure 6. The BBS is a widely used clinical test of human balance and is now a standardised method for testing balance function. The Berg Balance Scale implemented in this system is shown in Figure 6. 14 items are scored

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on the Berg Balance Scale, with a minimum score of 0 and a maximum score of 4 for each item, for a total score of 56. The results of the Berg Balance Scale are divided into 3 groups according to the score of 0-20, 21-40 and 41-56. The first group indicates that the patient has poor balance and needs a wheelchair, the second group indicates that the patient has some balance but needs assistance when walking, and the third group indicates that the patient has good balance and can walk independently.

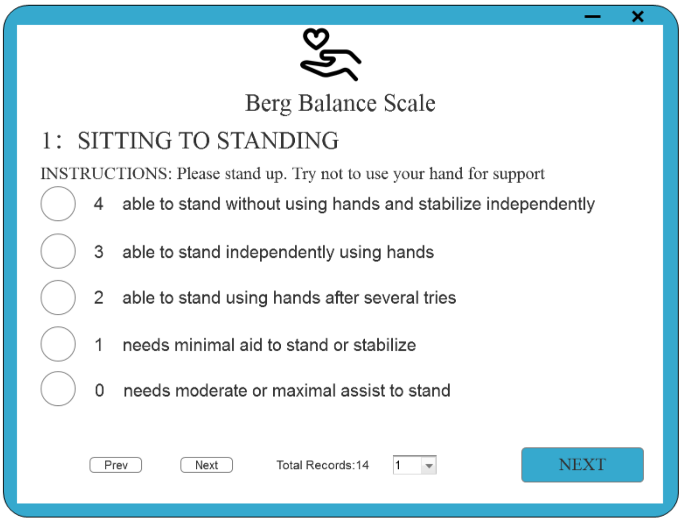

Figure 6: Berg Balance Scale interface.

2.2.3. Barthel Index

Mahoney and Barthel first proposed the Barthel Index, a scale for assessing patients' ability to perform activities of daily living. It is used in clinical practice [17]. The Barthel Index interface is shown in Figure 7, with 10 specific assessment items such as feeding, bathing, dressing and toileting. A score of 10 is given according to the degree of dependence on a particular activity, with a score of 10 for complete self-care and 0 for complete dependence. The Barthel Index is obtained by adding up the scores. A score of 60 or above is considered good, indicating that the patient has mild functional impairment but is able to take care of himself; a score of 41 to 60 indicates that the patient has moderate functional impairment and needs assistance from devices or others in daily life; a score of 40 or below indicates that the patient has severe functional impairment. According to the analysis of clinical results, the most effective rehabilitation treatment is provided when the Barthel Index score is above 40.

Figure 7: Barthel Index interface.

2.2.4. The Functional Independent Measure

The Functional Independent Measure (FIM) is a tool developed by the US Department of Rehabilitation Medicine to assess the severity of a patient's disability and has been widely tested and clinically used. The FIM interface is shown in Figure 8, which is used to assess the patient's ability in six areas. Independence is scored from 6 to 7 and dependence is scored from 1 to 5. A score of 7 is given for

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being able to complete an activity independently and within a set time frame without the use of an appliance; a score of 6 is given for one or more of the following: requiring an appliance to assist with the activity, taking too long to complete, or having safety concerns while performing the activity; a score of 5 is given for requiring minimal physical assistance and the patient is able to complete 75% or more of the activity; a score of 4 is given for requiring a small amount of physical assistance; a score of 3 is given for 50%-75% of the activity requiring more assistance than light contact; a score of 2 is given for 25%-50% of the activity requiring significant assistance; and a score of 1 is given for complete dependence on others, with less than 25% of the activity being completed by the patient on their own.

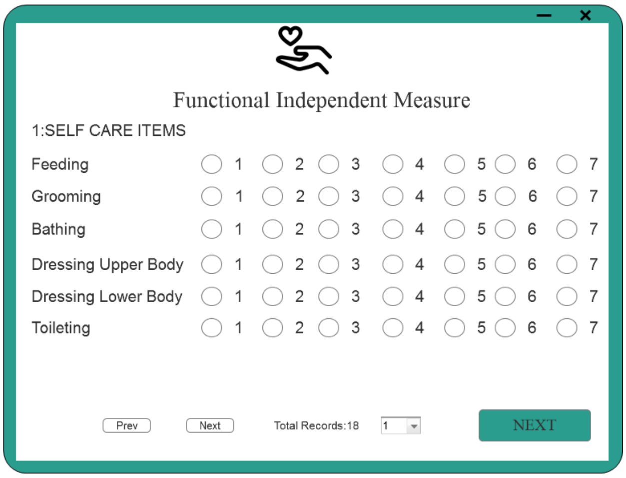

Figure 8: Functional Independent Measure interface.

2.2.5. Boston Diagnostic Aphasia Examination

Aphasia is a language impairment syndrome in which previously acquired language skills are impaired as a result of brain injury. Aphasia is assessed in terms of talking, repetition, oral comprehension, naming, reading and writing[18]. The Boston Diagnostic Aphasia Examination is one of the commonly used diagnostic tests for aphasia [19] and includes both verbal and non-verbal function tests. The Boston Diagnostic Aphasia Examination is generally divided into five sections with 26 sub-assessments, which are more detailed but more time-consuming. This scale can measure the function of each component of language and can be used to determine the severity of aphasia, classify aphasia, and quantitatively analyse the patient's level of verbal communication, etc. The interface for assessing the severity of aphasia implemented in this system is shown in Figure 9.

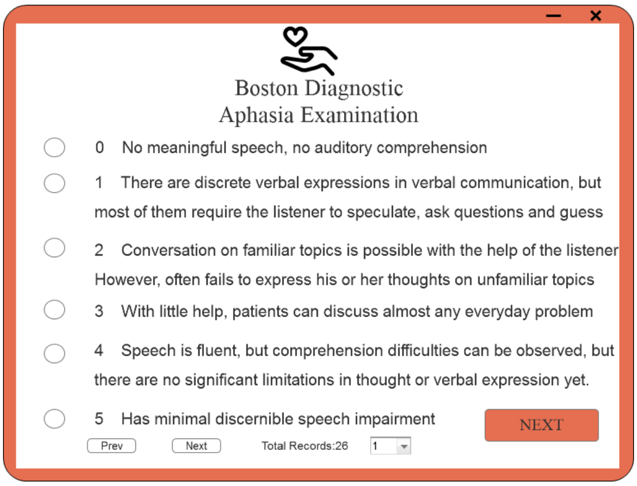

Figure 9: Boston Diagnostic Aphasia Examination interface.

2.2.6. Hamilton Depression Scale

The Hamilton Depression Scale (HAMD) was first introduced by Hamilton in 1960 [20] and has been frequently used to assess depression in clinical practice since its inception. Two specially trained staffs are required to assess the depressive state of patients using this scale. The main methods used in the assessment are conversation and observation, with the two staffs scoring the patient independently during

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the examination, usually before and after the patient has received treatment. The results are generally divided into four categories: 0-6, normal; 7-17, possible depression; 18-24, definite depression; 25 or more, severe depression.

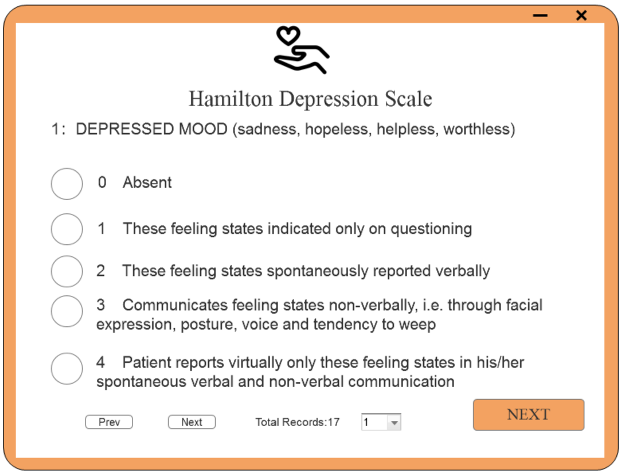

Figure 10: Hamilton Depression Scale interface.

3. Conclusions

After the COVID-19 pandemic, the appeal for home-based telerehabilitation grows. How to work efficiently online is a huge challenge for telerehabilitation, and the degree of informatization of rehabilitation assessment, which is the core of rehabilitation medicine, directly determines the efficiency of rehabilitation treatment. This paper provides rehabilitation assessment software that can help hospital rehabilitation departments to develop and evaluate patient-centred home telerehabilitation programmes for a wide range of conditions. Based on the patient's rehabilitation assessment results, the rehabilitation physician can equip each patient with a professional remote intelligent rehabilitation device. The rehabilitation physician can use the intelligent device to accurately understand the patient's current training status in real time and adjust the training parameters in a timely manner. In future design and development, we will enhance the link between rehabilitation assessment and rehabilitation treatment and the interaction with remote intelligent rehabilitation devices.

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