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Article

Development of Exercise Prescriptions for People with Impaired Vestibular Function

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Abstract: Objective: The aim is to develop a scientific and systematic exercise prescription to help people with impaired vestibular function intervene in symptoms through systematic exercise training. Methods: A random sampling method was used to select samples of people with impaired vestibular function for this experiment from the group with poor vestibular function stability. Before the subjects received a 6-week exercise prescription intervention, they underwent vestibular function tests, balance function tests, etc. Subsequently, they carried out systematic training according to the designed exercise prescription. The training content included vestibular function rehabilitation training exercises, balance training, visual target training, vestibular reflex training, etc. The training was conducted three times a week, with each training session lasting about 60 min for 6 weeks. After the training, various evaluations were carried out again to assess the effectiveness of the exercise prescription. Results: After 6 weeks of systematic training, the subjects' vestibular function, balance ability, and visual adjustment ability were all improved. Specifically, the visual adjustment coefficient score was (6.92 ± 0.06) points, which was higher than (6.65 ± 0.07) points before the intervention; the balance stability coefficient score was (8.65 ± 0.10) points, which was higher than (9.23 ± 0.25) points before the intervention; the somatosensory coefficient score was (6.67 ± 0.05) points, which was higher than (6.97 ± 0.08) points before the intervention; the balance index score was (42.99 ± 24.75) points, which was higher than (49.40 ± 18.64) points before the intervention; the vegetative function score was (2.69 ± 0.06) points, which was higher than (2.90 ± 0.07) points before the intervention; the somatic motor score was (1.44 ± 0.69) points, which was higher than (2.53 ± 0.74) points before the intervention. Difference is statistically significant ($p < 0.05$). Conclusion: The exercise prescription for people with impaired vestibular function can improve the patients' balance ability and postural control ability, thus improving their quality of life. Therefore, developing a scientific and systematic exercise prescription is of great significance for the rehabilitation of people with impaired vestibular function.

Keywords: vestibular function; exercise prescription; rehabilitation exercises; impaired vestibular function

1. Introduction

In recent years, the number of people with impaired vestibular function has been on the rise continuously [1]. Vestibular function impairment triggered by causes such as vertigo and vestibular neuritis will degrade the quality of life of patients [2]. Patients commonly resort to drug treatment and vestibular rehabilitation therapy (VRT) [3]. In view of the disadvantages of drug treatment and traditional VRT, the development of exercise prescriptions is of great significance. Exercise prescriptions have been extensively applied in numerous fields [4]. There may be broad

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prospects for their application in improving the impaired balance ability of the vestibular function, the balance ability during horizontal and rotational movements, spatial perception ability, visual response ability, as well as attention and cognitive ability. The exercise prescription for people with impaired vestibular function [5] is a scientific and systematic functional exercise method. To determine its application value, this study mainly conducts an analysis on the sampled specimens, and the report is presented as follows.

2. Data and Methods

2.1. General Data

A random sampling method was used to select 55 samples of people with impaired vestibular function for this experiment from the group with poor vestibular function stability. There were 28 males and 27 females, with ages ranging from 20 to 52 years old.

2.2. Exercise Prescription

2.2.1. Vestibular Function Rehabilitation Training Exercises

Head-turning and body-turning movements: Conduct them slowly to the extent that no dizziness or vertigo is induced. Each group consists of 15 times, with 6 groups in total, and an interval of 30 s to 1 min between each group.

Walking forward, backward, left, and right: Perform on a flat, spacious, and obstacle-free ground, gradually increasing the speed and difficulty. Each group has 20 times, with 6 groups in total, and an interval of 30 s to 1 min between each group.

Side-step gliding: Conduct under the guidance of professionals to ensure safety.

Exercise intensity: The average heart rate during exercise is 80–100 beats per minute.

Exercise time and frequency: Each exercise session lasts 30–50 min, 3 times a week for 6 weeks.

2.2.2. Balance Training

Static balance function training: Such as standing on one foot, standing with eyes closed, etc., gradually increasing the difficulty from easy to difficult. Each group lasts 30 s to 1 min, with 6 groups in total, and an interval of 1–2 min between each group.

Dynamic balance training: Such as standing-stance left-right striding training, left-right foot alternating standing training, etc., paying attention to maintaining stability. Each group has 30 strides, with 6 groups in total, and an interval of 1–2 min between each group.

Exercise intensity: The average heart rate during exercise is 100–120 beats per minute.

Exercise time and frequency: Each exercise session lasts 40–60 min, 3 times a week for 6 weeks.

2.2.3. Visual Target Training

Place objects at different distances in front of the field of vision and conduct gaze and line-of-sight transfer exercises, which helps to improve the vestibular-ocular reflex function. Each group lasts 30 s to 1 min, with 6 groups in total, and an interval of 1–2 min between each group.

Exercise intensity: The average heart rate during exercise is 80–100 beats per minute.

Exercise time and frequency: Each exercise session lasts 30–50 min, 3 times a week for 6 weeks.

2.2.4. Vestibular Reflex Training

Perform actions such as turning the head, nodding, bending over, and picking up things while lying in bed to enhance the compensatory ability of the vestibular system. Each group has 30 times, with 6 groups in total, and an interval of 1–2 min between each group.

Exercise intensity: The average heart rate during exercise is 80–100 beats per minute.

Exercise time and frequency: Each exercise session lasts 30–50 min, 3 times a week for 6 weeks.

2.2.5. Precautions

Safety first: During the exercise process, ensure the safety of patients and avoid accidents such as falls.

Proceed step by step: The difficulty and intensity of exercise training should increase step by step to avoid over-training that may exacerbate symptoms.

Continuous training: The recovery of impaired vestibular function requires time and patience. Patients should adhere to continuous training to achieve the best results.

Regular evaluation: During the training process, monitor the patients' exercise performance and physiological responses in real-time, such as heart rate, blood pressure, and blood oxygen saturation. Regularly evaluate the changes in patients' symptoms and balance ability to adjust the exercise prescription in a timely manner.

2.3. Intervention Evaluation

(1) Static balance tests were conducted using the above-mentioned balance tester, the Newbalance Balance Tester (Omeizhilu Health Co., Ltd. Located Room 702, Block B, Jinyu Jiahua Building, No. 9 Shangdi Third Street, Haidian District, Beijing) before and after the intervention: The patients were tested in a quiet, suitable environment free from any interfering factors. The tester explained the operation procedures and precautions to them. Then, the patients took off their shoes and slowly stood on the central detection platform, with their foot positions aligned with the baseline on the detection platform, and stood naturally while gazing at the marker in front. Monitoring items: (i) Visual adjustment coefficient [6]: It reflects the role of vision in postural control. The larger this value is, the greater the role of vision in postural control. Conversely, without the function of visual feedback, the body's balance function will deteriorate. (ii) Balance stability coefficient: It reflects the stability of the body. The larger the coefficient, the smaller the degree of swaying, and the better the body's stability. Below 10.2 is poor, 10.2–11.2 is slightly poor, 11.2–13.5 is moderate, 12.5–14.6 is good, and above 14.6 is excellent. (iii) Proprioceptive coefficient: It reflects the functional situation of proprioception in postural control. The larger the coefficient, the stronger the proprioceptive postural adjustment ability, and it is relatively easier to maintain balance. Below 7.4 is poor, 7.4–8.7 is slightly poor, 8.7–11.4 is moderate, 11.4–12.7 is good, and above 12.7 is excellent. (iv) Balance index: It is a comprehensive score of the overall balance ability of the visual, vestibular, and proprioceptive systems.

(2) Vegetative function [7]: Score according to the vestibular organ function stability scoring table formulated by Luchanov and Pochinkov (Table 1). Instructions for using the scoring table: Check the scoring table according to the differences in the pulse and blood pressure of the subjects within 10 s before and after rotation. For example, the pulse of a certain subject is 11 times per 10 s and the arterial blood pressure is 15.42/8.51 kPa when at rest; after rotation, the pulse is 13 times per 10 s and the arterial blood pressure is 16.22/8 kPa. That is to say, the pulse increases by 2 times after rotation, and the highest blood pressure rises by 0.8 kPa. According to the change in the pulse rate at the top of the scoring table and the change in the highest blood pressure indicated on the left side of the table, the intersection point of the vertical column of numbers for a pulse rate change of +2 and the horizontal row of numbers for a highest blood pressure change of 0.8 is "4", and this "4" is the score value. The smaller the changes in the pulse and blood pressure of the subjects before and after rotation, the higher the score obtained, that is, the higher the stability of the vestibular organ function. A score below 3 indicates poor stability.

The subject sits on the rotating chair, closes his/her eyes, leans the head forward at an angle of 30°, and rotates evenly for 10 rounds at a rotation speed of one round every 2 s. After the rotation stops, the subject immediately raises his/her head, opens the eyes, stands up, and walks along the straight line, trying his/her best to control himself/herself to walk along the straight line to the 6-m mark. After the rotation stops, if the subject can walk normally along the median straight line, or the deviation from the median straight line does not exceed 0.25 m, it indicates good functional stability of the vestibular organ, and a score of 5 points is given. If the subject can walk the 6-m distance with a deviation from the median straight line not exceeding 0.5 m, a score of 4 points is given. If the subject can walk the 6-m distance with a deviation from the median straight line not exceeding 1 m, a score of 3 points is given. If the subject cannot stand up within 2 s, or the deviation from the median straight line exceeds 1 m during walking, 2 points are given. This indicates poor functional stability of the vestibular organ and is rated as failing.

Table 1. Scoring Table for the Functional Stability of the Vestibular Organ.

	The Change Inpulse Rate (10 s)	**+5**	**+4**	**+3**	**+2**	**+1**	**0**	**−1**	**−2**	**−3**	**−4**	**−5**	**−6**
The change in the highest blood pressure (kPa)	4.00	–	–	2.0	2.25	2.5	2.75	–	–	–	–	–	–
	3.45	–	2.0	2.25	2.5	2.75	3.0	2.5	–	–	–	–	–
	3.05	2.0	2.25	2.5	2.75	3.0	3.25	2.75	–	–	–	–	–
	2.67	2.25	2.5	2.75	3.0	3.25	3.5	3.0	2.5	–	–	–	–
	2.26	2.5	2.75	3.0	3.35	3.5	3.75	3.25	2.75	2.0	–	–	–
	1.86	2.75	3.0	3.35	3.5	3.75	4.0	4.25	3.75	2.5	2.0	–	–
	1.46	3.0	3.25	3.5	3.75	4.0	4.25	3.75	3.25	2.75	2.25	–	–
	1.06	3.25	3.5	3.75	4.0	4.25	4.50	4.0	3.5	3.0	2.5	–	–
	0.66	3.5	3.75	4.0	4.25	4.5	4.75	4.25	3.75	3.25	2.75	–	–
	±0.26	3.75	4.0	4.25	4.5	4.75	5.0	4.5	4.0	3.5	3.0	2.5	2.0
	−0.66	2.5	3.0	3.5	4.0	4.5	4.75	4.25	3.75	3.25	2.75	–	–
	−1.06	2.25	2.75	3.25	3.5	4.0	4.25	3.7	3.25	2.75	2.25	–	–
	−1.46	–	2.5	2.75	3.0	3.5	3.75	3.25	2.75	2.25	–	–	–
	−1.86	–	–	2.25	2.5	3.0	3.25	2.75	2.25	–	–	–	–
	−2.26	–	–	–	2	2.5	2.75	2.25	–	–	–	–	–

2.4. Statistical Methods

The SPSS 26.0 statistical software was applied for data analysis. Enumeration data were expressed as percentages (%) and analyzed using the chi-square (χ^2) test. Measurement data were expressed as ($\bar{x} \pm s$) and analyzed using the *t*-test. A *p*-value less than 0.05 was considered to indicate a statistically significant difference.

3. Results

After 6 weeks of intervention (Table 2), the visual adjustment coefficient score of the subjects was (6.92 ± 0.06) points, which was higher than (6.65 ± 0.07) points before the intervention, and the difference was statistically significant ($p < 0.05$); the balance stability coefficient score was (8.65 ± 0.10) points, which was higher than (9.23 ± 0.25) points before the intervention, and the difference was statistically significant ($p < 0.05$); the somatosensory coefficient score was (6.67 ± 0.05) points, which was higher than (6.97 ± 0.08) points before the intervention, and the difference was statistically significant ($p < 0.05$); the balance index score was (42.99 ± 24.75) points, which was higher than (49.40 ± 18.64) points before the intervention, and the difference was statistically significant ($p < 0.05$); the vegetative function score was (2.69 ± 0.06) points, which was higher than (2.90 ± 0.07) points before the intervention, and the difference was statistically significant ($p < 0.05$); the somatic motor score was (1.44 ± 0.69) points, which was higher than (2.53 ± 0.74) points before the intervention, and the difference was statistically significant ($p < 0.05$).

Table 2. Scores of Various Coefficients before and after the Intervention.

Title	**Before the Intervention**	**After the Intervention**	**t**	***p***
Visual adjustment coefficient	6.65 ± 0.07	6.92 ± 0.06	−10.705	0.000
Balance stability coefficient	8.65 ± 0.10	9.23 ± 0.25	−11.29	0.000
Proprioceptive coefficient	6.67 ± 0.05	6.97 ± 0.08	−10.74	0.000
Balance index	42.99 ± 24.75	49.40 ± 18.64	−24.37	0.000
Score of vegetative function	2.69 ± 0.06	2.90 ± 0.07	−8.97	0.000
Score of somatic function	1.44 ± 0.69	2.53 ± 0.74	−8.05	0.000

4. Discussion

The vestibular system is a fundamental component of the body's spatial orientation and balance systems. When the vestibular system is damaged, the patient's auditory function, visual function, balance function, etc. will all be affected to a certain extent, leading to problems such as unsteady gait and visual instability [8]. Once vestibular function impairment occurs, the normal work and life of patients will be disrupted, reducing their quality of life. Patients often use drug treatment and vestibular rehabilitation therapy [9]. Given the disadvantages of drug treatment and traditional VRT, the formulation of exercise prescriptions becomes particularly important.

The exercise prescription for people with vestibular function impairment is a scientific and systematic functional exercise method. In improving the impairment of patients with vestibular function impairment, this intervention method can promote the improvement of patients' vestibular function through means such as vestibular function rehabilitation training exercises, balance training, visual target training, and vestibular reflex training, providing good support for the improvement of their sensory integration disorder (auditory, visual, kinesthetic) symptoms.

This study designed a training program for patients with vestibular function impairment, which consists of two parts: exercise prescription formulation and vestibular function assessment. Among them, the vestibular function rehabilitation training exercises and visual target training in the exercise prescription can improve the obstruction of the vestibulo-ocular reflex [10] pathway in patients with vestibular function impairment, helping patients to reconstruct a good visual reflex; vestibular reflex training provides support for the recovery of the motor integration function [11] of patients with vestibular dysfunction; and balance training can correct the balance disorder of patients with vestibular function impairment and improve their motion illusion vertigo [12] condition. The vestibular function assessment can present clear and intuitive vestibular function assessment results, facilitating the understanding of the training effectiveness of the recently formulated exercise prescription, and appropriately adjusting the exercise prescription based on this to further promote the improvement of the body functions of people with vestibular function impairment.

In the rehabilitation process of patients with vestibular function impairment, the application advantages of formulating exercise prescriptions for people with vestibular function impairment are as follows: Personalized exercise prescription library: Establish a scientific personalized exercise prescription library to provide scientific and systematic exercise prescription options for patients with vestibular function impairment; Scientific assessment system: Construct a scientific assessment system. After the formulation and implementation of the exercise prescription, checking scores such as its visual adjustment coefficient, balance stability coefficient, somatosensory coefficient, balance index, vegetative function, and somatic motor ability can objectively and accurately evaluate the rehabilitation effect of the patient's vestibular function and the treatment effect of the exercise prescription; Improvement of rehabilitation effect: Through the implementation and optimization of personalized exercise prescriptions, this study shows that after 6 weeks of systematic training, the vestibular function, balance ability, and visual adjustment ability of the subjects have all improved. Combination of scientific research and clinical practice: Promote the close combination of scientific research and clinical practice, and promote the development of academic research and clinical practice in the field of rehabilitation for people with vestibular function impairment.

In conclusion, in the vestibular function rehabilitation of people with vestibular function impairment, the formulation and implementation of exercise prescriptions can improve vestibular function and quality of life. Therefore, scientific and systematic exercise prescriptions are of great significance for the rehabilitation of people with vestibular function impairment.

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Conflicts of Interest

The authors declare no conflict of interest.

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