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A Study on the Application Effect of the Joint Rehabilitation Intervention Based on the Hospital-Community-Family Model for Middle-Aged and Elderly Patients with Chronic Kidney Disease

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Abstract: *Objective:* To explore the application effect of the hospital-community-family model-based combined rehabilitation exercise intervention on middle-aged and elderly patients with chronic kidney disease. *Methods:* Using the convenience sampling method, 80 patients in the stable stage of CKD who were treated in the nephrology department of a tertiary hospital from May 2022 to June 2023 were selected as the research subjects. They were divided into the experimental group (40 cases) and the control group (40 cases) by random number table method. The control group received conventional exercise intervention plus telephone follow-up, while the experimental group received combined hospital-community-family model-based exercise intervention in addition to the control group, using remote medical guidance and monitoring of the application effect of exercise rehabilitation on middle-aged and elderly patients with chronic kidney disease. The glomerular filtration rate, 6-minute walking distance, fatigue and social support scores of the two groups of patients were measured before the intervention, 4 weeks after the intervention, and 12 weeks after the intervention. *Results:* Before the intervention, there were no statistically significant differences in glomerular filtration rate, 6-minute walking distance, fatigue and social support scores between the two groups ($p > 0.05$). After 12 weeks of intervention, the glomerular filtration rate, 6-minute walking distance and social support scores of the experimental group were higher than those of the control group; the differences were statistically significant ($p < 0.05$). The behavioral, emotional, sensory and cognitive scores of the Piper-Fatigue Revised Scale of the experimental group were lower than those of the control group, and the differences were statistically significant ($p < 0.05$). *Conclusion*: Based on the hospital-community-family model combined rehabilitation exercise, using remote medical guidance for the continuous care of middle-aged and elderly patients in the stable stage of chronic kidney disease can effectively improve the exercise endurance and social support level of patients, improve the fatigue condition, and the implementation effect is positively correlated with the intervention time.

Keywords: Hospital-community-family model; Remote medical care; Middle-aged and elderly people; Chronic kidney disease patients; Rehabilitation exercise

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1. Introduction

Chronic kidney disease (CKD) refers to a decline in kidney function, characterized by a glomerular filtration rate (GFR) lower than 60 mL/min/1.73 m^2, or the detection of kidney damage markers, with a duration of at least 3 months [1]. The global prevalence of CKD is 9.1%, and the prevalence in China is 8.2% [2,3]. The average age of patients with CKD is 43.8 years, and middle-aged and elderly patients have become the main population of CKD in China. CKD can lead to a decline in patients' self-care ability, and restricting activities can cause muscle atrophy, fatigue, and more, further aggravating the patient's condition and reducing their quality of life, and making the physiological and psychological dysfunction problems of patients increasingly prominent [4–7].

The construction of the hospital-community-family linkage model not only improves the treatment level of nurses at the community and other grassroots levels, but also enables the three to coordinate and develop, allowing the community and family to fully play their roles and provide effective continuous care for patients [8]. Through remote medical forms such as remote assessment, remote monitoring, remote diagnosis, and remote rehabilitation [9]. It effectively improves the treatment effect of patients and delays the progression of the disease [10–13].

In the 2021 "Clinical Practice Guidelines for Exercise and Lifestyle in Chronic Kidney Disease" issued by the British Kidney Society, it is emphasized that CKD patients should, when their physical conditions permit, use low-intensity activities to break the long-term sedentary state. In the expert consensus on exercise rehabilitation for adult patients with chronic kidney disease in China, it is pointed out that regular exercise can improve the body function, muscle strength, and health-related quality of life of CKD patients [14–15].

This study conducts rehabilitation exercise intervention guidance and monitoring for CKD patients based on the hospital-community-family model to help patients undergo exercise rehabilitation and then assess the rehabilitation effect of the combined rehabilitation exercise intervention based on the hospital-community-family model for patients.

2. Objectives and methods

2.1. Research subjects

This study continuously included 80 middle-aged and elderly patients with stable CKD who were treated in the nephrology ward of a tertiary hospital in Hebei Province from May 2022 to June 2023 as the research subjects. Using the random number table method, the enrolled patients were divided into the experimental group and the control group, with 40 patients in each group.

2.1.1. Inclusion criteria

Meeting the definition of CKD proposed by the American Kidney Disease Prognosis Quality Guidelines, with a disease course of ≥ 3 months; clinically diagnosed stable CKD stages 1 to 4, and not undergoing maintenance dialysis treatment; middle-aged and elderly patients aged ≥ 45 years; having independent walking ability and being able to complete the individualized exercise prescription as required under guidance; long-term residence after discharge within the community covered by the hospital's remote medical platform; being able to communicate without obstacles with the researchers, voluntarily participating throughout the study, and signing an informed consent form.

2.1.2. Exclusion criteria

Unconsciousness, patients with mental disorders; those who cannot cooperate with exercise due to other reasons, such as post-stroke sequelae, fractures, or severely deformed limbs due to deformities; those with severe heart, liver, brain, lung and other serious kidney diseases; those currently participating in clinical trials. There was no statistically significant difference in the general data between the two groups ($p > 0.05$).

2.2. Intervention methods

Development of exercise prescription: The exercise prescription was formulated based on the "Clinical Practice Guidelines for Exercise Rehabilitation in Chronic Kidney Disease" [15].

(1) Exercise form

Mainly aerobic exercises, including resistance training such as gymnastics, walking, cycling, and swimming; flexibility training such as sandbags, elastic bands, Tai Chi, yoga, and Baduanjin.

(2) Exercise intensity

Adjust the exercise intensity according to the results of the exercise test. Start with activities within the subjective exertion score range of 11–13, gradually increasing to a subjective exertion score range of 11–16.

(3) Exercise frequency

Aerobic exercise starts with 2 times per week, gradually increasing to 3–5 times per week; resistance training starts with 2 non-consecutive days per week, and can be increased to 3 times per week; flexibility training is 5 times per week.

(4) Exercise duration

Including 5–10 minutes of warm-up before exercise, 20–30 minutes of exercise duration, and 5–10 minutes of relaxation after exercise. The total duration of each session is 30–60 minutes.

2.2.1. Control group

The control group received routine care from the nephrology department. The routine care measures included as follow.

(1) When the patient was admitted, the nephrology nurses introduced the department environment to the patient and their family members, assisted the patient in undergoing relevant examinations, established a good nurse-patient relationship, and understood the patient's health needs.

(2) During hospitalization, the physician and rehabilitation therapist formulated an appropriate exercise prescription for the patient, and the nephrology nurses provided exercise guidance and routine post-discharge health education to the patient; the researchers introduced the characteristics, complications, and adverse outcomes of chronic kidney disease to the patient and their caregivers, enhancing the patient's understanding of the disease.

(3) After discharge, they received routine community services, including chronic disease-specific management provided by the community health center and monthly health education classes

(4) For patients with chronic kidney disease at home, the nephrology nurses provided a one-time telephone follow-up service, mainly educating the patient on precautions for home exercise.

2.2.2. Experimental group

On the basis of conventional treatment and care, a combined rehabilitation program based on the hospital-community-family model is implemented, and intervention care is carried out through a remote medical platform. The specific intervention measures are as follows.

(1) Establish a remote platform and a movement intervention team

The team members consist of 2 nephrology specialists, 1 exercise rehabilitation therapist, 2 nephrology nurses, 2 community nurses, and 1 remote platform engineer. The nephrology specialists and exercise rehabilitation therapists are responsible for prescribing individualized exercise regimens for patients based on their conditions and exercise capabilities; the nephrology nurses are responsible for providing relevant education before exercise training, explaining the content and precautions of the exercise prescription, and coordinating the time and content of regular video conferences between the remote platform and the patients after the patients are discharged; the remote platform engineer is responsible for the use and maintenance of the platform.

(2) Remote exercise and health management content

Two remote exercise supervision and follow-up sessions are conducted every week. Online exercise supervision and guidance. Firstly, warm-up exercise for each session lasts for 10 minutes. Secondly, aerobic exercise by brisk walking or cycling exercise.

The brisk walking exercise is carried out at a rate of 100–200 steps per minute; cycling exercise is done 5 km each time, 2 times a day, 10 minutes each time; c. Resistance exercise: elastic band exercise or dumbbell exercise. Pull the elastic band with both hands forcefully, parallelly raise when inhaling, and return to the original position when exhaling; perform left and right stretching, one arm pulling the other arm, stretching the outer side of the upper arm and extending the armpit.

Pull with force when inhaling, and return when exhaling. 3 sets per day, 10 per set; d. Stretching exercise: After each exercise session, patients perform 15 minutes of stretching exercise. The rehabilitation therapist checks the accuracy of the patient's exercise prescription and asks the patient if their daily exercise meets the prescription standards, supervises their exercise compliance, and asks if they experience any physical discomfort during the exercise. Adjust according to the changes in the patient's exercise ability.

Online consultation, for example patients can consult hospital or community medical staff via remote platform in the form of text, language, pictures or videos

Online health education, for example, nephrology specialist nursing experts can conduct online education lectures every month. The lecture content is determined according to the patients' needs, mainly focusing on the prevention of acute and chronic complications and lifestyle guidance for middle-aged and elderly CKD patients.

(3) Patient-side operation of the remote platform

Researchers release videos related to chronic kidney disease rehabilitation exercise on the remote medical platform of a tertiary hospital in Hebei Province every Monday, Wednesday and Friday, for patients, community medical staff and caregivers to learn, to increase the enthusiasm of patients to participate in exercise rehabilitation training.

2.3. Observation indicators

During the follow-up visit of the patient, data collection was conducted. The observation indicators included as below.

(1)Glomerular Filtration Rate

Glomerular Filtration Rate (GFR) refers to the volume of ultrafiltrate produced by both kidneys within a unit of time, and is used to evaluate the filtration function of the kidneys. The calculation method for estimated glomerular filtration rate (eGFR): The Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation is adopted (**Table 1**).

Table 1. CKD-EPI equations for estimating GFR based on gender, serum creatinine (Scr), and age

Gender	Scr(μmol/L)	GFR(CKD-EPI) [$mL^{-1}\times(1.73m^2)^{-1}$]
Female	≤ 62	$144 \times (Scr/62)^{-0.329} \times 0.993^{age}$
	> 62	$144 \times (Scr/62)^{-1.209} \times 0.993^{age}$
Male	≤ 80	$144 \times (Scr/80)^{-0.411} \times 0.993^{age}$
	> 80	$144 \times (Scr/80)^{-1.209} \times 0.993^{age}$

(2) 6-minute walk test

The 6-minute walk test (6MWT) is an effective assessment tool for chronic diseases, evaluating the patient's exercise endurance by measuring the distance they can walk in 6 minutes, and determining the exercise function and rehabilitation effect.

(3) Fatigue

The Piper-Fatigue Revised Scale is used to evaluate the degree of fatigue of the patients. This scale consists of 22 items, divided into 4 dimensions (behavior, emotion, perception, and cognition). The scoring method for the items is a 0–10 points grading system. The total score of the scale is calculated as the average score of the included items. Fatigue is classified into four levels based on the score: none (0 points), mild (1–3 points), moderate (4–6 points), and severe (7–10 points). The score range is from the lowest 0 points to the highest 10 points. The higher the score, the heavier the perceived fatigue. The Cronbach's α coefficient of this scale is 0.97, indicating good reliability and validity [16].

(4) Social support

The Social Support Rating Scale (SSRS) compiled by Xiao Yuanwater et al. is used to assess the degree of social support [17]. This scale includes 3 dimensions: "objective support, subjective support, and utilization of social support", with a total of 10 items. It uses a 4-point rating system, with a total score ranging from 10 to 40 points. The higher the score, the higher the degree of social support.

2.4. Statistical methods

The data were analyzed using SPSS 25.0 statistical software. For the measurement data that conformed to the normal distribution, the mean ± standard deviation was used to represent them. Paired *t*-test was employed for comparisons between groups; repeated measures analysis of variance was used for comparisons within the three different time groups. A difference was considered statistically significant when $p < 0.05$.

3. Results

3.1. Comparison of glomerular filtration rate between the two groups of patients

The comparison of glomerular filtration rate between the two groups of patients before intervention, 4 weeks after intervention, and 12 weeks after intervention is shown in **Table 2**.

Table 2. Comparison of glomerular filtration rate before and after intervention between the two groups of patients (mL/min, $\bar{x} \pm s$)

Time	Prior treatment	Treatment for 4 weeks	Treatment for 12 weeks
Experimental group	86.867 ± 12.772	87.006 ± 12.648	99.367 ± 8.349
Control group	87.172 ± 12.710	87.097 ± 12.648	84.007 ± 9.286
F value	$F_{Intergroup}$4.074	F_{Time}31.447	$F_{Interaction}$85.872
t value	-0.515	-0.146	13.112
p value	0.609	0.885	< 0.001

Before intervention in both groups of patients, the glomerular filtration rate was compared, and the difference was not statistically significant ($p > 0.05$); at 4 weeks after intervention, the glomerular filtration rate of patients in the experimental group and those in the control group was compared, and the difference was statistically significant ($p < 0.05$); after 12 weeks of intervention, the glomerular filtration rate of patients in the experimental group and those in the control group was compared, and the difference was statistically significant ($p < 0.05$).

3.2. Comparison of 6-minute walking distance indicators between the two groups of patients

The comparison of 6MWD between the two groups of patients including 3 timelines, first before intervention, second, 4 weeks after intervention, and third, 12 weeks after intervention is shown in **Table 3**.

Table 3. Comparison of 6MWD before and after intervention between the two groups (m, $\bar{x} \pm s$)

Time	Prior treatment	Treatment for 4 weeks	Treatment for 12 weeks
Experimental group	316.545 ± 29.218	335.295 ± 28.296	370.570 ± 24.636
Control group	311.195 ± 22.652	320.920 ± 22.888	320.920 ± 24.636
F value	$F_{Intergroup}$23.197	F_{Time}320.931	$F_{Interaction}$ 152.641
t value	1.332	5.928	14.025
p value	0.191	< 0.001	< 0.001

Before intervention, a comparison of 6MWD was conducted between the two groups of patients, and the difference was not statistically significant ($p > 0.05$); at 4 weeks after intervention, the 6MWD comparison between the patients in the experimental group and the control group showed a statistically significant difference ($p < 0.05$); after 12 weeks of intervention, the 6MWD comparison between the patients in the experimental group and the control group yielded a statistically significant result ($p < 0.05$).

3.3. Comparison of fatigue conditions between the two groups of patients

The comparison of fatigue scores of the two groups of patients before the intervention, 4 weeks after the intervention, and 12 weeks after the intervention is presented (see **Table 4**). Before the intervention, the scores of each dimension of fatigue and the total score of the two groups of patients were compared, and the difference was not statistically significant ($p > 0.05$); 4 weeks after the intervention, the scores of the two groups of patients in the two fatigue dimensions (behavior, emotion) and the total score showed a statistically significant difference ($p > 0.05$); 12 weeks after the intervention, compared with the control group, the scores of each dimension and the total score of fatigue in the experimental group showed statistically significant differences ($p < 0.05$).

Table 4. Comparison of fatigue levels before and after intervention in the two groups of patients (points, $\bar{x} \pm s$)

Measure	Time	Experimental group	Control group	*F* value	*t* value	*p* value
Behavioral	Prior treatment	3.024 ± 0.762	3.143 ± 0.897	$F_{Intergroup}$21.874	-0.421	0.676
	Treatment for 4 weeks	2.486 ± 0.718	3.018 ± 1.086	F_{Time}51.470	-3.418	0.001
	Treatment for 12 weeks	1.364 ± 0.513	2.898 ± 1.019	$F_{Interaction}$29.056	-8.809	< 0.001
Affective	Prior treatment	3.440 ± 0.879	3.623 ± 1.037	$F_{Intergroup}$16.462	-1.656	0.106
	Treatment for 4 weeks	2.890 ± 0.998	3.491 ± 1.020	F_{Time}92.215	-4.187	< 0.001
	Treatment for 12 weeks	1.784 ± 0.498	3.340 ± 1.068	$F_{Interaction}$42.278	-9.452	< 0.001
Sensory	Prior treatment	3.213 ± 0.733	3.414 ± 0.602	$F_{Intergroup}$20.407	-2.001	0.052
	Treatment for 4 weeks	3.186 ± 0.651	3.273 ± 0538	F_{Time}136.189	-0.797	0.430
	Treatment for 12 weeks	1.828 ± 0.611	3.264 ± 0.609	$F_{Interaction}$107.753	-12.847	< 0.001
Cognitive	Prior treatment	2.007 ± 0.566	2.038 ± 0.563	$F_{Intergroup}$4.983	-0.621	0.538
	Treatment for 4 weeks	1.911 ± 0.555	1.975 ± 0.553	F_{Time}20.071	-1.688	0.990
	Treatment for 12 weeks	1.279 ± 0.737	1.998 ± 0.791	$F_{Interaction}$18.419	-5.007	< 0.001
Total Score	Prior treatment	2.930 ± 0.427	3.055 ± 0.370	$F_{Intergroup}$59.800	-1.846	0.073
	Treatment for 4 weeks	2.619 ± 0.420	2.939 ± 0.375	F_{Time}77.00	-5.489	< 0.001
	Treatment for 12 weeks	1.564 ± 0.301	2.875 ± 0.438	$F_{Interaction}$77.00	-16.042	< 0.001

3.4. Comparison of social support between the two groups of patients

Comparison of social support between the two groups of patients before intervention, 4 weeks after intervention, and 12 weeks after intervention (see **Table 5**).

Table 5. Comparison of social support levels before and after intervention in the two groups of patients (points, $\bar{x} \pm s$)

Time	Prior treatment	Treatment for 4 weeks	Treatment for 12 weeks
Experimental group	33.717 ± 1.540	33.737 ± 1.270	37.755 ± 1.748
Control group	34.165 ± 1.357	34.206 ± 1.270	34.492 ± 1.609
F value	$F_{Intergroup}$7.577	F_{Time}147.091	$F_{Interaction}$109.031
t value	-1.481	-1.774	9.292
p value	0.147	0.084	< 0.001

Before intervention, the scores of social support for the two groups of patients were compared, and the difference was not statistically significant ($p > 0.05$); at 4 weeks after intervention, the social support situation of the two groups of patients was compared, and the difference was not statistically significant ($p > 0.05$); after 12 weeks of intervention, the social support situation of the patients in the experimental group and the control group was compared, and the difference was statistically significant ($p < 0.05$).

4. Discussion

4.1. The joint rehabilitation exercise intervention based on the hospital-community-family model can effectively improve the renal function of CKD patients

The research results indicated that after 12 weeks of intervention, the GFR of the experimental group was higher than that of the control group, and the difference was statistically significant ($p < 0.05$). This suggests that the hospital-community-family model combined with rehabilitation exercise intervention can effectively improve the renal function of patients, and the improvement degree is higher than that of conventional exercise intervention combined with telephone follow-up. The possible reason for this is that the hospital-community-family model combined with rehabilitation exercise intervention utilizes both remote monitoring and remote rehabilitation in telemedicine, which makes patients more compliant with exercise, more confident, and more likely to complete the designated exercise intervention plan.

4.2. The combined rehabilitation program based on the hospital-community-family model can effectively enhance the exercise endurance of patients with chronic kidney disease

The clinical characteristics of CKD patients show that as renal function declines, cardiopulmonary endurance begins to deteriorate, and muscle atrophy leads to a decrease in self-care ability, seriously affecting the quality of life of patients. Studies [18–20] have shown that appropriate aerobic exercise combined with resistance exercise can effectively improve the activity ability and quality of life of patients.

Low physical activity can effectively delay the further development of CKD, but excessive physical activity can also increase the burden on the kidneys. The lack of professional exercise guidance and examination after discharge can lead to impaired exercise ability and decreased physical function in CKD patients, resulting in periodic decreases in physical activity levels and ultimately functional disorders [21]. The results of this study show that the 6-minute walking distance of patients in the experimental group was higher than that of the control group, indicating that the exercise endurance of patients was effectively improved, which is consistent with the research results of Chen Jiale et al [22].

The possible reason for this is that the joint rehabilitation exercise intervention based on the hospital-community-family model can effectively supervise patients to carry out rehabilitation training through the remote medical platform, and the exercise compliance of patients may be higher than that of conventional exercise intervention and telephone follow-up supervision.

4.3. The combined rehabilitation program based on the hospital-community-family model can effectively alleviate the fatigue symptoms of patients with chronic kidney disease

The main effects of total score of the fatigue scale over time, intervention, and the interaction between time and intervention were statistically significant ($p < 0.05$). This indicates that fatigue will alleviate over time and also will be alleviated as the exercise intervention progresses. Moreover, the combined rehabilitation exercise intervention based on the hospital-community-family model has a proportional improvement effect on the fatigue level of CKD patients with the intervention time. The longer the intervention time, the better the improvement effect.

4.4. The combined rehabilitation intervention based on the hospital-community-family model can effectively enhance the social support level of CKD patients

Social support is an independent risk factor for anxiety and depression in CKD patients [23]. Improving the level of social support for patients can effectively reduce their risk of depression, slow down the progression of the disease, and improve their quality of life. The results of the repeated-measures variance analysis in this study showed that the social participation scores of both groups were higher than those before the intervention after 4 weeks and 12 weeks of intervention, proving that both exercise intervention programs can effectively improve the social support level of patients. There was a statistically significant difference in the total social participation scores of the two groups after 4 weeks and 12 weeks of intervention ($p < 0.05$).

The social participation score of the experimental group was higher than that of the control group, indicating that the combined rehabilitation exercise intervention based on the hospital-community-family model is more effective in improving the social support level of patients than the conventional method. The possible reason for this is that the remote medical platform enables the family members of patients to effectively participate in the entire process of the exercise rehabilitation treatment of the patients, allowing the patients to receive more encouragement and assistance from family members, community staff, and medical staff.

5. Conclusion

In conclusion, this study provides exercise guidance to CKD patients through a combined rehabilitation exercise intervention based on the hospital-community-family model. By using a three-dimensional linkage system of hospital-community-family, it achieves full-process care for CKD patients, improves their renal function, enhances their exercise endurance, reduces fatigue, improves social support levels, and comprehensively improves their physical and mental health levels and quality of life. However, the current scope of hospital-community-family linkage is relatively small, and the results may be biased. In the future, multi-center, stratified sampling studies can be conducted to make the results more extensible and scientific.

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