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Observation on the Effect of Combined Exercise Intervention Based on the Hospital-Community-Family Model on Intrinsic Capacity in Elderly Patients with Diabetes Mellitus Complicated by Chronic Kidney Disease

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Abstract: *Objective*: To explore the application effect of combined exercise intervention based on the hospital-community-family model on intrinsic capacity in elderly patients with diabetes mellitus complicated by chronic kidney disease. *Methods*: Using convenience sampling, 100 elderly patients with diabetes mellitus complicated by chronic kidney disease who received treatment in the endocrinology department of a tertiary A-level hospital from May 2024 to May 2025 were selected as the study subjects. They were randomly divided into an experimental group (50 cases) and a control group (50 cases) using a random number table method. The control group received routine health education and telephone follow-up, while the experimental group, in addition to the control group's interventions, underwent combined exercise intervention based on the hospital-community-family model. Remote medical guidance was utilized to monitor and study the application effect of exercise intervention on intrinsic capacity in elderly patients with diabetes mellitus complicated by chronic kidney disease. Fasting blood glucose, 2-hour postprandial blood glucose, glomerular filtration rate, 6-minute walk distance, and scores in five dimensions of intrinsic capacity (exercise, cognition, psychology, vitality, and sensation) were measured before the intervention, at 4 weeks of intervention, and at 12 weeks of intervention for both groups. *Results:* Before the exercise intervention, there were no statistically significant differences ($p > 0.05$) between the two groups in terms of fasting blood glucose, 2-hour postprandial blood glucose, glomerular filtration rate, 6-minute walk distance, and scores across five dimensions of intrinsic capacity: mobility, cognition, psychology, vitality, and sensation. After 12 weeks of intervention, the experimental group demonstrated significantly higher scores than the control group in glomerular filtration rate, 6-minute walk distance, and the dimensions of mobility, cognition, and vitality within intrinsic capacity, with all differences being statistically significant ($p < 0.05$). Conversely, the experimental group showed significantly lower scores than the control group in fasting blood glucose, 2-hour postprandial blood glucose, and the psychological dimension of intrinsic capacity, with these differences also being statistically significant ($p < 0.05$). *Conclusion:* Continuous nursing care utilizing telemedicine based on a hospital-community-family model combined with exercise intervention can effectively enhance exercise tolerance and intrinsic capacity in elderly patients with diabetes mellitus complicated by chronic kidney disease, thereby improving their quality of life. The effectiveness of the intervention is positively correlated with the duration of the intervention.

Keywords: Hospital-community-family model; Telemedicine; Elderly; Diabetes mellitus complicated by chronic kidney disease; Intrinsic capacity

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1. Introduction

As the process of population aging accelerates, the co-occurrence of chronic diseases in the elderly has become a major concern in the field of public health [1]. Both diabetes mellitus (DM) and chronic kidney disease (CKD) are prevalent chronic conditions among the elderly population, often interacting and progressing in tandem. This not only exacerbates renal function impairment and elevates the risk of end-stage renal disease (ESRD), but also triggers a series of issues such as physical function decline and cognitive impairment [2]. Approximately 30–50% of patients with concurrent DM and CKD eventually develop ESRD, posing a severe threat to their quality of life [3]. The concept of intrinsic capacity (IC), introduced by the WHO in 2015 as a core indicator for assessing the health status of the elderly, encompasses multiple dimensions including physical capacity, cognition, psychology, and social adaptation. The level of IC directly determines the elderly's ability to live independently and their health prognosis, serving as an important metric for evaluating the effectiveness of chronic disease management [4]. It aims to reflect the overall state of the elderly from a holistic perspective and can be used as an independent predictor of disability in the elderly [5]. Current exercise intervention models are mostly confined to short-term guidance within hospitals, lacking continuous supervision at the community level and long-term cooperation at the family level, making it difficult to meet the personalized and long-term intervention needs of elderly patients with comorbidities [6,7]. The hospital-community-family integrated intervention model breaks down the barriers of healthcare service settings. Through telemedicine service platforms, it integrates tertiary healthcare resources, achieving full-process coverage from standardized in-hospital diagnosis and treatment to continuous community management and then to daily home care, providing new approaches for the comprehensive management of elderly patients with chronic diseases [8–11]. Therefore, this study aims to explore the implementation of exercise intervention guidance and monitoring for elderly patients with diabetes mellitus (DM) complicated by chronic kidney disease (CKD) based on a hospital-community-family model, and subsequently evaluate its application effect on patients' intrinsic capacity, with the goal of providing a reference basis for further improving the quality of life of elderly patients with DM complicated by CKD.

2. Subjects and methods

2.1. Subjects

This study consecutively enrolled 100 elderly patients with DM complicated by CKD who received treatment in the Endocrinology Department of a tertiary-level hospital from May 2024 to May 2025. Using a random number table method, the enrolled patients were divided into an experimental group and a control group, with 50 cases in each group.

2.1.1. Inclusion criteria

Participants meeting the diagnostic criteria for DM with a disease duration of ≥ 3 months; conforming to the definition of CKD proposed by the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines, with clinically confirmed stable CKD stages 1–4, and not undergoing maintenance dialysis treatment; elderly patients aged ≥ 60 years; individuals capable of independent walking and able to complete individualized exercise prescriptions for this study as instructed; long-term residence after discharge within the community covered by the hospital's telemedicine platform; able to communicate without barriers with researchers, willing to participate throughout the study, and having signed an informed consent form [12,13].

2.1.2. Exclusion criteria

Individuals with severe osteoarticular diseases, such as ankylosing spondylitis; those with mental disorders combined with severe heart, liver, brain, lung, or other serious renal diseases; and those currently participating in clinical trials. There were no statistically significant differences in general data between the two groups ($p > 0.05$).

2.2. Intervention methods

Exercise intervention involves the formulation of individualized exercise prescriptions. The exercise prescriptions are developed with reference to the "Chinese Guidelines for Exercise in Type 2 Diabetes" and the "Clinical Practice Guidelines for Exercise Rehabilitation in Chronic Kidney Disease" [14,15]. Specific guidance is provided on exercise form, intensity, frequency, and duration.

2.2.1. Control group

The control group receives conventional care for DM combined with CKD.

2.2.2. Experimental group

In addition to conventional treatment and care, the experimental group undergoes a joint exercise intervention based on a hospital-community-family model utilizing a telemedicine platform. The specific measures are as follows:

(1) Establish a remote platform and an exercise intervention team
The team members include: 1 endocrinologist, 1 nephrologist, 1 exercise rehabilitation therapist, 1 endocrine specialist nurse, 1 nephrology specialist nurse, 2 community nurses, and 1 remote platform engineer.

(2) Remote exercise and health management content
Remote exercise supervision and follow-up will be conducted twice a week, including: ① Online exercise supervision and guidance: a. Warm-up exercises for 10 minutes each time; b. Aerobic exercises; c. Resistance exercises; e. Flexibility exercises; f. Stretching exercises. ② Online medical consultations: Patients can consult hospital or community healthcare professionals online through the remote platform using text, voice, images, or video. ③ Online health education: Monthly online educational lectures will be conducted by endocrine or nephrology specialist nursing experts.

(3) Remote platform patient-side operations

Researchers will release videos related to rehabilitation exercises for diabetes mellitus (DM) and chronic kidney disease (CKD) on the hospital's telemedicine platform every Tuesday and Thursday for patients, community healthcare professionals, and caregivers to learn from, thereby enhancing patients' enthusiasm for participating in exercise rehabilitation.

2.3. Observation indicators

Data will be collected during patient follow-up visits, with observation indicators including: fasting blood glucose, 2-hour postprandial blood glucose, glomerular filtration rate, 6-Minute Walk Test (6MWT), and intrinsic capacity scores for the elderly. Intrinsic capacity encompasses five dimensions: exercise, cognition, psychology, vitality, and sensation.

(1) Short physical performance battery (SPPB)

The SPPB comprises four major tests: balance ability test, walking speed test, and sit-to-stand test. A score of 1 is assigned for a performance time ranging from 16.7 to 60 seconds, 2 points for a time between 13.70 and 16.69 seconds, 3 points for a time between 11.20 and 13.69 seconds, and 4 points for a time of ≤ 11.19 seconds. If the task cannot be completed or the time exceeds 60 seconds, a score of 0 is given. Each test component is scored from 0 to 4, resulting in a total SPPB score of 12 points. An SPPB score of ≤ 8 indicates decreased physical performance [16].

(2) Mini mental state examination (MMSE)

The MMSE is currently one of the preferred screening tools for cognitive impairment, developed by Folstein [17]. The scale includes assessments of orientation, memory, attention and calculation, recall ability, and language skills. The total score is 30 points, with higher scores indicating better cognitive function. It demonstrates high reliability and validity when used to evaluate dementia in various populations.

(3) Mini nutritional assessment (MNA)

The MNA scale, developed by Guigoz et al., includes six items: ① weight loss in the last three months; ② body mass index; ③ psychological stress or acute illness in the last three months; ④ mobility; ⑤ psychological problems; and ⑥ appetite in the last three months. The total score is 14 points, and a score of ≤ 11 points suggest a decline in the vitality dimension [18].

(4) Short-form geriatric depression scale (geriatric depression scale 5 items, GDS-15)

The GDS-15 was developed by foreign scholar Sheikh in 1986 and consists of 15 items, with a total score of 15 points. Each item answered as indicative of depression is scored as 1 point, and a final score of ≥ 8 points indicates the presence of depressive symptoms [19].

(5) Sensory dimension scoring

The sensory dimension includes vision and hearing. Vision and hearing are assessed using a visual acuity chart and a whisper test, respectively. Normal vision and hearing are scored as 1 point, while any impairment is scored as 0 points.

2.4. Statistical methods

Data were analyzed using SPSS 25.0 statistical software. Normally distributed measurement data are presented as mean ± standard deviation ($\bar{x} \pm s$). Comparisons between groups were conducted using paired *t*-tests, while comparisons within three different time groups were performed using repeated measures analysis of variance. A *p*-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of fasting blood glucose level between two groups of patients

A comparison of fasting blood glucose levels between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is presented in **Table 1**.

Table 1. Comparison of fasting blood glucose level between two groups before and after intervention (mol/L, $\overline{x} \pm s$)

Time point	Before treatment	4 Weeks of treatment	12 Weeks of treatment
Experimental group (n = 50)	10.2 ± 2.7	8.6 ± 2.4	7.9 ± 2.3
Control group (n = 50)	10.7 ± 1.3	10.2 ± 1.2	10.0 ± 2.2
F-value (ANOVA)	$F_{Group}4.045$	$F_{Time}35.484$	$F_{Interaction}82.679$
t-value (vs. Baseline)	-0.523	-0.152	12.115
p-value	0.609	< 0.001	< 0.001

3.2. Comparison of 2-hour postprandial blood glucose levels between the two groups

A comparison of 2-hour postprandial blood glucose levels between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 2**.

Table 2. Comparison of 2-hour postprandial blood glucose levels between the two groups before and after intervention (mol/L, $\overline{x} \pm s$)

Time point	Before treatment	4 Weeks of treatment	12 Weeks of treatment
Experimental group (n = 50)	11.8 ± 2.2	9.8 ± 2.6	8.8 ± 2.1
Control group (n = 50)	10.7 ± 2.1	10.5 ± 1.2	10.3 ± 2.6
F-value (ANOVA)	$F_{Group}4.127$	$F_{Time}30.258$	$F_{Interaction}81.367$
t-value (vs. Baseline)	-0.520	-0.137	13.109
p-value	0.341	< 0.001	< 0.001

3.3. Comparison of glomerular filtration rates between the two groups

A comparison of glomerular filtration rates between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 3**.

Table 3. Comparison of glomerular filtration rates between the two groups before and after intervention (mL/min, $\overline{x} \pm s$)

Time point	Before treatment	4 Weeks of treatment	12 Weeks of treatment
Experimental group (n = 50)	86.867 ± 12.775	87.003 ± 12.342	99.367 ± 8.349
Control group (n = 50)	87.172 ± 12.710	87.097 ± 12.548	84.007 ± 9.286
F-value (ANOVA)	$F_{Group}4.112$	$F_{Time}32.243$	$F_{Interaction}84.637$
t-value (vs. Baseline)	-0.417	-0.118	12.284
p-value	0.609	< 0.001	< 0.001

3.4. Comparison of the six-minute walk distance (6MWD) between the two groups

A comparison of the 6MWD between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 4**.

Table 4. Comparison of the 6MWD between the two groups before and after intervention (m, $\overline{x} \pm s$)

Time point	Before treatment	4 Weeks of treatment	12 Weeks of treatment
Experimental group (n = 50)	306.245 ± 27.218	325.295 ± 27.296	369.570 ± 24.635
Control group (n = 50)	301.185 ± 23.652	319.920 ± 24.878	322.820 ± 26.423
F-value (ANOVA)	F_{Group}22.287	F_{Time}318.572	$F_{Interaction}$148.529
t-value (vs. Baseline)	1.283	5.647	14.193
p-value	0.685	< 0.001	< 0.001

3.5. Comparison of intrinsic capacities between the two groups

A comparison of scores across five dimensions of intrinsic capacity between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 5**.

Table 5. Comparison of intrinsic capacities between the two groups before and after intervention (points, $\overline{x} \pm s$)

Dimension	Time point	Experimental group (n = 50)	Control group (n = 50)	*F*-value	*t*-value	*p*-value (Group difference)
Motor	Before Intervention	5.05 ± 2.82	4.83 ± 1.86	F_{Group}23.856	-0.463	0.629
	4 Weeks	5.32 ± 2.42	4.75 ± 1.79	F_{Time}50.672	-3.582	0.061
	12 Weeks	7.54 ± 2.16	4.82 ± 1.61	$F_{Interaction}$28.652	-8.792	< 0.001
Cognitive	Before Intervention	18.27 ± 2.61	18.62 ± 2.34	F_{Group}15.445	-1.639	0.106
	4 Weeks	21.24 ± 1.92	18.97 ± 1.69	F_{Time}82.315	-4.085	0.087
	12 Weeks	25.37 ± 1.54	19.68 ± 1.28	$F_{Interaction}$41.285	-9.257	< 0.001
Psychological	Before Intervention	6.44 ± 2.83	6.52 ± 1.92	F_{Group}20.526	-2.023	0.171
	4 Weeks	4.21 ± 1.56	6.32 ± 1.27	F_{Time}121.284	-0.761	0.227
	12 Weeks	3.19 ± 1.84	5.86 ± 1.53	$F_{Interaction}$106.251	-12.568	<0.001
Vitality	Before Intervention	10.12 ± 1.42	9.89 ± 1.86	F_{Group}4.564	-0.582	0.489
	4 Weeks	10.29 ± 1.29	10.12 ± 1.39	F_{Time}20.128	-1.752	0.864
	12 Weeks	11.86 ± 1.81	10.19 ± 1.56	$F_{Interaction}$18.812	-5.127	< 0.001
Sensory	Before Intervention	0.32 ± 0.71	0.31 ± 0.89	F_{Group}56.261	-1.728	0.161
	4 Weeks	0.33 ± 0.76	0.32 ± 0.23	F_{Time}72.729	-1.453	0.121
	12 Weeks	0.34 ± 0.68	0.35 ± 0.38	$F_{Interaction}$73.592	-1.039	0.258

4. Discussion

4.1. Hospital-community-family exercise intervention improves glycemic control in elderly DM-CKD patients

Joint exercise intervention based on the hospital-community-family model can effectively improve fasting blood glucose and 2-hour postprandial blood glucose levels in elderly patients with diabetes mellitus (DM) complicated by chronic kidney disease (CKD). The study results indicate that after 4 and 12 weeks of intervention, both fasting blood glucose and 2-hour postprandial blood glucose levels in the experimental group were significantly lower than those in the control group, with statistically significant differences ($p < 0.05$). This suggests that the intervention can effectively reduce blood glucose levels in patients, and the effect of reducing blood glucose is positively correlated with the duration of the intervention, with longer durations yielding more pronounced effects. The analysis suggests that the intervention may leverage remote monitoring and guidance models in telemedicine to ensure the safety and scientific validity of patient exercise, while providing continuous supervision and motivation from family members or peers, leading to higher adherence, incorporation into daily habits, and long-term maintenance, thereby effectively achieving blood glucose control goals.

4.2. Hospital-community-family exercise intervention improves renal function in elderly DM-CKD patients

Joint exercise intervention based on the hospital-community-family model can effectively improve renal function in elderly patients with DM complicated by CKD. The results of this study indicate that after 12 weeks of intervention, the glomerular filtration rate (GFR) in the experimental group was higher than that in the control group, with a statistically significant difference ($p < 0.05$). This suggests that the intervention can effectively improve renal function in patients. The analysis suggests that the intervention may leverage both remote monitoring and remote rehabilitation in telemedicine to enhance patient exercise adherence, boost confidence, and increase the completion rate of designated exercise intervention programs.

4.3. A hospital-community-family rehabilitation exercise model improves exercise capacity in elderly DM-CKD patients

Joint rehabilitation exercise intervention based on the hospital-community-family model can effectively improve exercise capacity in elderly patients with DM complicated by CKD. Studies have shown that appropriate aerobic exercise combined with resistance training can effectively improve patients' mobility and quality of life, while low physical activity can effectively delay the further progression of diabetes mellitus (DM) and chronic kidney disease (CKD) [20–22]. However, 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 capacity and a decline in physical function levels among elderly patients with DM complicated by CKD, resulting in periodic reductions in physical activity levels and ultimately functional disorders [23]. The results of this study indicate that the 6-minute walk distance of patients in the experimental group was higher than that in the control group, suggesting that patients' exercise capacity was effectively improved, consistent with the findings of studies by Chen Jiale and others [24].

4.4. A multi-level rehabilitation exercise intervention improves intrinsic capacity in elderly patients with diabetic kidney disease

Rehabilitation exercise intervention based on a hospital-community-family model can effectively improve the intrinsic capacity of elderly patients with DM complicated by CKD. Intrinsic capacity serves as an independent predictor of disability in the elderly [25]. Studies have shown that a decline in intrinsic capacity affects the daily living abilities of the elderly [26]. Improving patients' intrinsic capacity can effectively delay disease progression, reduce the risk of complications, and enhance their quality of life. The results of repeated measures analysis of variance in this study showed no statistically significant difference in the scores of the sensory dimension of intrinsic capacity between the two groups after 4 and 12 weeks of intervention ($p > 0.05$). However, statistically significant differences were observed in the scores of the motor, cognitive, psychological, and vitality dimensions of intrinsic capacity between the two groups after 4 and 12 weeks of intervention ($p < 0.05$). It is proven that this intervention can significantly improve the levels of patients' intrinsic abilities in terms of exercise, cognition, psychology, and vitality. The analysis suggests that the reason may be that the combination of telemedicine platforms and exercise interventions can promote the effective participation of patients' family members in the entire process of patients' exercise rehabilitation treatment, enabling patients to receive more encouragement and assistance from family members, community staff, and medical personnel.

5. Conclusion

In summary, this study employed a hospital-community-family model combined with exercise interventions and utilized telemedicine platforms to provide exercise guidance for elderly patients with diabetes mellitus (DM) complicated by chronic kidney disease (CKD). This approach aimed to deliver comprehensive nursing care throughout the entire process for these patients, improve their blood glucose levels, enhance renal function, boost their intrinsic abilities, and ultimately improve their quality of life. However, given that telemedicine and digital smart nursing technologies are not yet fully widespread, and the scope of hospital-community-family collaboration is relatively limited, the results may be subject to bias. Therefore, future multi-center studies could be conducted to enhance the scientific rigor of the findings.

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Disclosure statement

The authors declare no conflict of interest.

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