Original Article

Effect of exercise rehabilitation combined with calcitriol on renal function health of patients undergoing maintenance hemodialysis

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Abstract

Background A key concern for global health systems is the rising incidence & prevalence of chronic renal disease. There is very little access to treatment for the condition. The primary goals of the study were to examine patient survival patterns and identify risk factors of poor outcomes in end-stage renal disease patients receiving maintenance hemodialysis.

Objective The main objective of this study was to investigate whether exercise rehabilitation coupled with calcitriol affected the renal function health of individuals on maintenance hemodialysis.

Methods The research participants were 120 individuals with chronic renal failure who were hospitalized in our hospital for continuous maintenance hemodialysis between September 2018 to September 2021. The randomized selection approach was used to split 60 cases into two groups: control and test. The control group received calcitriol, whereas the test group received exercise therapy mixed with calcitriol. Serum nitrogen, serum creatinine, serum calcium, serum phosphorus, and plasma albumin levels were compared between the two groups, as were parathyroid hormone levels, the fatigue inventory-14.

Results The levels of blood phosphorus and parathyroid hormone were decreased, and the test group was better than the control group ($P<0.05$). Before treatment, there was no statistical significance in the total score of FS-14, body fatigue score, and mental fatigue score between the 2 groups ($P>0.05$). After treatment, the total score of FS-14, physical fatigue, and mental fatigue were significantly lower than before treatment ($P<0.05$). Lower limb functioning and livability scores were considerably greater after treatment than before ($P<0.05$.

Conclusion Exercise rehabilitation coupled with calcitriol offers some promise in treating calcium and phosphorus levels as well as renal failure in patients on maintenance hemodialysis, while also improving patients' tiredness and living standards.

Keywords: sports rehabilitation, calcitriol, hemodialysis, renal function [Ethiop. J. Health Dev. 2023: 37(1) (00-00)]

Introduction

The frequency of chronic renal failure has grown dramatically in past years as human beings' living structures have changed, and the number of patients getting maintenance hemodialysis has progressively increased (Lai et al., 2017). Maintenance hemodialysis, on the other hand, can cause a slew of issues in patients, including decreased cardiopulmonary function, muscle atrophy, and physical and psychological dysfunction, all of which have a negative impact on the patient's quality of life and add to the burden on families and society (Perl et al., 2017; Dashtidehkordi, Shahgholian, & Attari, 2019). Studies have shown that exercise rehabilitation can improve cardiorespiratory endurance, increase muscle strength, relieve dialysis-related non-specific symptoms, improve nutritional status and psychological function in maintenance hemodialysis patients, thereby enhancing the overall standard of living score of maintenance hemodialysis patients and reducing the risk of mortality (Lopes et a1., 2014; Molfino et al., 2017). Calcitriol can directly activate vitamin D receptors on the parathyroid gland, inhibit the release of parathyroid hormone, and reduce related complications such as hypercalcemia and calcification. At the same time, intravenous treatment can enhance heart function, improve prognosis, and lower the risk of cardiovascular disease, all of which have substantial therapeutic implications (Alfieri et al., 2019; Duque, Elias, & Moys és, 2020). Health-related quality of life (HRQoL) is low for dialysis patients with end-stage renal diseases (ESRD) compared to the general population. Existing research suggests that physical symptoms also play key roles in this unsatisfactory HRQoL, along with a high burden of comorbid disease, decreased physical function, and other variables (Flythe et al., 2015). When assessing the quality of life in relation to health, generic instruments are intended to be used across a wide range of patient populations and clinical settings, whereas illness-specific instruments can explain the unique effects of a particular disease (Gumprecht et al., 2010). Physical functioning & mental health are two examples of topics that generic instruments may evaluate and are commonly believed to be highly valued by the general public. In order to compare people independently of their unique conditions, "generic" multidimensional HRQOL measures are used to offer information on function and well-being (Unruh & Hess, 2007). This study examines and monitors the impact of exercise rehabilitation coupled with calcitriol on renal performance in maintenance hemodialysis participants in order to guarantee that hemodialysis runs smoothly and that patients' prognoses are improved. The following is the report:

Materials and methods

General information

The research subjects were 120 patients with chronic renal failure who received maintenance hemodialysis in our hospital between September 2018 and September 2021. They were separated into a control group of 60

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cases and a test group of 60 cases using the randomly selected procedure. There were 36 men and 24 females in the test group; their ages varied from 22 to 72 years, with an average of (54.17±8.59) years; and their dialysis time ranged from 10 to 38 months, with an average of (15.42±4.20). The control group consisted of 33 males and 27 females; the age ranged from 25 to 76 years, with an average age of (53.22±6.05) years; the dialysis time was 9 to 40 months, with an average of (15.42±3.93) months. There was no considerable variance in basic information among the two groups (P>0.05). Inclusion criteria: ① Chronic renal failure diagnosed by clinical manifestations and related laboratory tests, aged 20-75 years; ② Maintaining hemodialysis for ≥6 months, stable condition; ③ Not receiving other related treatments, the patient is conscious and has good compliance ④ All patients were anticoagulated with low molecular weight heparin, dialysis 3 times a week, 4 hours each time, and the dialysate flow was 500 mL/min; ⑤ The consent forms were signed by the patients after the hospital ethics committee approved it. Exclusion criteria: ① Those with severe heart, brain, liver, and kidney dysfunction, or diseases of the hematopoietic system and endocrine system; ② Those with severe infections and malignant tumors; ③ Those with mental, memory, and intellectual disabilities who are unable to cooperate; ④ For Patients with severe allergic reactions to study drugs and hemodialyzers; ⑤ Pregnant and lactating women.

Methods

All enrolled patients received routine maintenance hemodialysis. Dialysis program: OBERS-3000 hemodialysis machine and polyethersulfone membrane hollow fiber dialyzer (membrane area 1.5m^2) were used. The blood access is an arteriovenous fistula or a deep venous catheter, the dialysate is bicarbonate solution, the blood flow is 200-250 mL/min, the dialysate flow is 500 mL/min, and the low molecular weight heparin anticoagulant is 3000-5000U each time. Each dialysis time is 4 hours, dialysis 3 times a week. The control group received calcitriol treatment, while the test group received exercise rehabilitation in addition to calcitriol treatment. At the end of intravenous dialysis, calcitriol (produced by AbbVie Pte. Ltd in Singapore, SFDA approval number H20160340, 1ml:1μg) is injected through the venous end of hemodialysis. The initial dose was 1-2ug/time, 2 times/week, After that, the dose is adjusted once every 2 to 4 weeks according to the blood calcium and the patient's tolerance, and the dose is adjusted to 0.5ug each time, and the maximum dose is 6ug/d.

Sports rehabilitation training includes 3 aspects: (1) Consult relevant books, make and distribute rehabilitation sports training brochures to patients, intuitively explain the reason, purpose, significance, and precautions of training to patients and their families, and inform the patient of the benefits of training to the patient and possible special situations, and the measures to be taken in special situations. Instruct patients to accurately record the content of daily rehabilitation training, including training time, intensity, heart rate changes, etc., to improve patient compliance. (2) Rehabilitation exercise training subjects include simple and safe aerobic exercises such as walking, jogging, table tennis, stair climbing, badminton, yoga, and Tai Chi. Based on the patient's individual fitness level, disease development, and the patient's personal preferences, the corresponding rehabilitation exercise training subjects are formulated. Furthermore, based on the patient's physical fitness status, determine the time of rehabilitation exercise training. Do not exercise on fasted or bellyful, and do warm-up or relaxation exercises before and after training. (3) Instruct patients to train 3-5 times a week, with an interval of more than 24 hours and less than 48 hours between two training sessions. Nursing professionals educate patients on how to measure their heart rate and advise them to do so when they exercise, and inform patients that their heart rate must be controlled below 70% of the maximum heart rate (220 beats/min) during exercise, and inform patients to immediately stop rehabilitative exercise training and contact caregiver if any physical discomfort occurs.

Observation indicator

(1) Renal function indicators: Prior to and after treatment, 6 mL of fasting venous blood was taken and centrifuged at 3000 r/min for 10 minutes. After centrifugation, an automatic biochemical analyzer was used to detect blood urea nitrogen (BUN), and blood Creatinine (Cr) levels.

(2) Biochemical indicators: 5ml of fasting cubital venous blood was taken in the morning before and after treatment in both groups and serum calcium (Ca), serum phosphorus (P), plasma albumin (Alb), parathyroid Adrenaline (iPTH) levels were measured after centrifugation.

(3) Dialysis fatigue status (Sigurdardottir et al., 2010): Fatigue scale-14 (FS-14) was used to assess fatigue, which includes physical fatigue score and mental fatigue level. The total tiredness score is the sum of the two scores, and the greater the score, the more severe the exhaustion.

(4) Lower extremity motor performance and standard of life level (Besnier et al., 2012; Ware & Sherbourne, 2019). The 6-minute walking test was used to examine lower extremities motor performance. (6MWT), which measured the walking distance within 6min. The SF-36 scale was performed to measure the patient's standard of living, and the percentage system was utilized to score, with the score being proportionate to the patient's standard of living.

(5) Keep track of any adverse responses in both groups during therapy.

Statistical analysis

The data was examined using SPSS 26.0 statistical tool; count data were represented as % and n, and the x2 test was used between groups; values obtained were represented as "$\overline{X}$ ±s", and the t-test was used between groups, with P0.05 as the variation was statically important.

Results

Comparison of renal function indexes

Prior to therapy, there was no statistical variation in serum creatinine or blood urine nitrogen levels among the two groups (P>0.05). However, after post-therapy, the levels of serum creatinine and blood urine nitrogen were considerably reduced in both groups, as indicated in Table 1.

Table 1. Assessment of renal function indexes among two groups ($\overline{X} \pm s$)

Group	Serum creatinine (umoL/L)		Blood urine nitrogen (mmoL/L)	
	Pre	Post	Pre	Post
Control group (n=60)	814.77±66.30	710.84±53.77*	25.09±2.50	20.71±1.29*
Test group (n=60)	820.47±68.88	667.55±69.54*#	25.77±2.25	17.03±1.21*#
T value	0.462	3.815	1.566	16.073
P value	0.645	0.000	0.120	0.000

Note: In comparison to pretreatment: *P<0.05, in comparison to the control group: #P<0.05.

Assessment of blood biochemical indexes
Prior to therapy, there was no major change in blood calcium, serum phosphorus, plasma albumin, or parathyroid hormone levels among the two groups (P>0.05). After therapy, serum calcium and plasma albumin levels increased in both groups; serum phosphorus and parathyroid hormone levels fell, and the test group performed better than the control group (P<0.05), as shown in Table 2.

Table 2. Assessment of blood biochemical indexes among two groups ($\overline{X} \pm s$)

Group	Blood calcium (mmoL/L)	Serum phosphorus (mmoL/L)	Plasma albumin (g/L)	Parathyroid hormone (ng/L)
Control group (n=60)				
Pre	1.79±0.24	2.44±0.27	33.08±3.16	260.63±33.61
Post	2.08±0.24*	2.04±0.19*	37.08±3.11*	202.12±36.07*
Test group (n=60)				
Pre	1.86±0.24	2.47±0.25	33.54±3.26	259.26±28.31
Post	2.34±0.22*#	1.84±0.17*#	40.34±3.75*#	231.14±26.01*#
T value	6.186	6.076	5.183	5.055
P value	0.000	0.000	0.000	0.000

Note: In comparison to pretreatment: *P<0.05, in comparison to the control group: #P<0.05.

Assessment of dialysis fatigue status scores
Before treatment, there was no major variation between the two groups in terms of FS-14 total score, physical fatigue score, and mental fatigue score (P>0.05); As is indicated in Table 3, the FS-14 total score, physical exhaustion score, and mental fatigue score were considerably lower post treatment than prior treatment (P<0.05), and the test group was considerably lesser (P<0.05).

Table 3. Assessment of dialysis fatigue status scores between the two groups ($\overline{X} \pm s$, points)

Group	Physical fatigue score		Mental fatigue score		FS-14 total score	
	Pre	Post	Pre	Post	Pre	Post
Control group (n=60)	6.90±1.80	5.83±1.47*	2.80±1.04	2.13±0.87*	9.15±2.02	6.77±1.73*
Test group (n=60)	7.02±1.50	5.10±1.50*#	2.93±1.09	1.30±0.53*#,	8.55±2.49	5.77±2.27*#
T value	0.392	2.597	0.459	6.470	1.469	2.671
P value	0.696	0.011	0.647	0.000	0.145	0.009

Note: In comparison to pretreatment: *P<0.05, in comparison to the control group: #P<0.05.

Assessment of lower extremity motor performance and quality of life scores
As is shown in Table 4, there was no considerable variation in lower extremity function and standard of living scores among the two groups before treatment

(P>0.05); lower extremity function and standard of living scores were significantly higher than those prior to treatment (P<0.05) and the test group was significantly higher than the control group (P<0.05).

Table 4. Assessment of lower extremity motor function and quality of life scores between the two groups ($\overline{X} \pm s$)

Group	Lower extremity function (m)		Quality of life scores (points)	
	Pre	Post	Pre	Post
Control group (n=60)	447.38±16.01	495.07±19.65*	38.17±6.88	68.37±7.86*
Test group (n=60)	450.18±20.14	540.48±21.61*#	39.77±6.92	78.40±7.86*#
T value	0.882	12.057	1.204	6.934
P value	0.379	0.000	0.231	0.000

Note: In comparison to pretreatment: *P<0.05, in comparison to the control group: #P<0.05.

Assessment of adverse reactions
Only one incidence of nausea occurred during treatment in the test group, which was recovered following symptomatic therapy, and no adverse response occurred in the control group.

Discussion
Chronic renal failure is a common and frequently-occurring disease that endangers human health. The course of the disease is usually progressive. If it progresses to end-stage renal disease, renal replacement treatment is necessary (Uster et al., 2018). Hemodialysis is one of the commonly used renal replacement therapies, but it is not a radical treatment. Because patients rely on hemodialysis for a long time, many dialysis-related complications will inevitably occur (Kim et al., 2018).
The key markers for assessing renal function are blood urea nitrogen and serum creatinine. When renal insufficiency is treated, blood urea nitrogen and serum creatinine levels rise in the body (Wang et al., 2017; Rehman et al., 2019). The levels of blood urea nitrogen and serum creatinine in the two groups were reduced following treatment, and the levels of blood urea nitrogen and serum creatinine in the test group were substantially lower than those in the control group. It shows that the research group can more obviously reduce the burden on the kidneys and has a positive regulating effect on the renal function status. In recent years, studies have focused on calcium and phosphorus metabolism and thyroid hormone disorders, and related evaluation indicators include Ca, P, Alb, and iPTH. Calcium exists in the serum of the body in the form of Ca^{2+}, which mainly controls the conduction of nerve impulses and maintains a state of balance under normal circumstances. The expression of serum calcium levels is affected by the pH value of the blood. pH value decreases, easy to dissociation and increase Ca^{2+}; otherwise, calcium-binding increases and Ca^{2+} decreases, and hypercalcemia can directly damage the kidney (Fukao et al., 2018; Lim et al., 2018). P is stored in the bone in the form of calcium phosphate, elevated expression levels are prone to hypoparathyroidism and chronic kidney disease, and reduced expression levels are prone to hyperparathyroidism (Bover et al., 2014; Almaden et al., 2010). IPTH is a hormone produced by the parathyroid gland's primary cells that may control calcium and phosphorus metabolism in the body, encourage the expression of Ca levels, and reduce P levels. The main target organ of iPTH is the kidney (Felsenfeld, Rodriguez, & Aguilera-Tejero, 2007; Kraenzlin & Meier, 2011). The findings of this research revealed that following therapy, serum calcium and plasma albumin levels increased in both groups; serum phosphorus and parathyroid hormone levels fell, and the test group was lower than the control group. This is because calcitriol is an active substance produced after the degradation of vitamin D3, and its synthesis is mainly in the kidneys of the human body. When the renal function of the human body is reduced, it will have a certain impact on the synthesis of calcitriol, resulting in the loss of calcium and the disorder of the body's blood P and blood Ca (Bodyak et al., 2017; Armas, Hollis, & Heaney, 2014). Therefore, it is speculated that calcitriol can protect the damaged kidney function by improving the level of calcium and phosphorus in the blood. Clinical studies have shown that many hemodialysis patients suffer from osteoporosis, muscle atrophy, and other symptoms due to long-term lack of exercise, coupled with the psychological pressure brought about by the disease, it is easy to make patients feel fatigued, aggravate the degree of fatigue of patients, and affect the quality of patients (Kim et al., 2018; Jenq et al., 2017). It can be seen from the results of pre-treatment that the psychological fatigue and physical fatigue of hemodialysis patients are at high levels. In order to reduce patient fatigue, measures should be taken for the above two reasons. Physical and mental weariness reduced dramatically following rehabilitation training in this research, and lower limb function and standard of living ratings increased significantly. The reason analysis may be as follows: (1) Appropriate rehabilitation exercise can improve the patient's appetite, promote protein synthesis, slow down or even eliminate muscle atrophy; (2) Regular rehabilitation exercise training can promote the patient to take in more nutrients and convert it into energy to enhance the patient's physical fitness; (3) Rehabilitation exercise training can enhance the patient's emotional condition, make the patient joyful, improve the patient's psychological condition, and decrease the patient's weariness (Baer-Bositis et al., 2018; Noguchi et al., 2015).

Conclusion

In conclusion, the addition of exercise rehabilitation training on the basis of calcitriol treatment has certain feasibility in the treatment of calcium and phosphorus levels and renal failure in maintenance hemodialysis patients, and at the same time, it can help people feel less tired and enhance their living standard.

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Statements and Declarations

The author declares that no conflict of interest is associated with this study.

Authors' contribution

This study was done by the authors named in this article, and the authors accept all liabilities resulting from claims related to this article and its contents.

Conflicts of interest

There are no conflicts of interest.

Availability of data and materials

The data used to support the findings of this study are available from the corresponding author upon request.

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