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MODERATE VERSUS LOW INTENSITY AEROBIC EXERCISE ON BONE MINERAL DENSITY IN PATIENTS ON HEMODIALYSIS

Strictly as per the compliance and regulations of:



Moderate Versus Low Intensity Aerobic Exercise on Bone Mineral Density in Patients on Hemodialysis

Nesreen G. El-Nahas ^α, Heba A. Bahey ^σ & Shimaa N. Aboelazm ^ρ

Abstract- Chronic kidney disease (CKD) is recognized as a major health problem reflecting the growing elderly population and increasing numbers of patients with diabetes and hypertension. Medical researches confronted with management of complex medical problems that are unique to patients with chronic renal impairment and renal dialysis where patients suffer from hypocalcemia that subjected them to osteoporosis.

Objective: The aim of this study was to compare the effect of two different intensities of aerobic exercises on bone mass density in patients on haemodialysis

Subjects: Thirty male patients underwent renal haemodialysis for 2 years ago with mean age (52.75 ± 4.51) were recruited from Police hospital.

Methods: They were assigned randomly into two groups, 15 patients in each group. Group (A) attended a program of moderate intensity aerobic treadmill exercise (60-70%MHR), where Group (B) attended a program of light intensity aerobic treadmill exercise (40-60%MHR), both for 6 months (3 sessions of exercise per week) prior to the dialysis session. Laboratory investigations for serum calcium and phosphorus level in addition to a dual X ray absorptimetry (DXA) were applied at baseline and after 6 months of training for both groups.

Results: The study revealed a significant difference in bone mineral density in favor of group A with P- value 0.01 as well as a significant increase in serum calcium by 12.29 %, 4.23 % and significant decrease in serum phosphorus with 21.67 %, 6.52 % for group A and B respectively. **Conclusion:** Moderate intensity aerobic exercise is more effective than light intensity aerobic exercise in modulating serum calcium and phosphorus and thus improving BMD in patients with hemodialysis.

Keywords: bone mass density /osteoporosis/ renal haemodialysis/ aerobic exercises.

I. INTRODUCTION

Chronic kidney disease (CKD) is a progressive condition that often comes with other multiple complications, such as diabetes, hypertension, re-

nal osteodystrophy, anemia, cardiovascular disease, and malnutrition. The earlier the recognition of CKD and treatment of its complications the better the long-term outcomes ⁽¹⁾. Kidneys have many important roles, such as regulating fluid and minerals in the body, they stimulate bone marrow to make red blood cells, synthesize vitamin D, regulate blood pressure, excrete waste chemicals in the urine and regulate acid-base levels. In kidney failure, the blood concentrations of calcium and phosphorus become abnormal. Calcium level drop is a condition called hypocalcaemia that can cause muscle weakness and nerve problems. In contrast, phosphorus levels rise. This is a condition called hyperphosphatemia, which can cause bone problems and itching. ⁽²⁾.

Hypocalcaemia occurs in kidney failure for at least two reasons. First, kidneys cannot synthesize vitamin D which normally raises the level of calcium in the body. Without vitamin D, calcium is not absorbed from the diet. Second, high levels of phosphate that could not bind to calcium deposit in the tissues as the diseased kidney could not excrete it. Low calcium levels encourage the release of parathyroid hormone (PTH). This hormone increases blood calcium by reabsorbing calcium from the bones. This can lead to a condition called renal osteodystrophy (ROD) ⁽³⁾. The syndrome known as chronic kidney disease-mineral and bone disorder (CKD-MBD) is composed of clinical, biochemical and radiological abnormalities where progressive bone loss and muscle cramping frequently occur ⁽⁴⁾.

Bone strength reflects the integration of two main features: bone density and bone quality. Bone density is expressed as grams of mineral per area or volume, and in any given individual is determined by peak bone mass and amount of bone loss. Bone quality refers to architecture, turnover, damage accumulation (e.g., microfractures) and mineralization ⁽⁵⁾. Normal bone density is defined as being (-1 standard deviation) or greater than the mean at 30-40 years (peak bone mass). Bone density between -1 SD and -2.5 SD of peak bone mass (T score between -1.5 and -2.5) has been defined by the WHO as osteopenia, and equal or below 2.5 SD of peak bone mass (a T score ≤ -2.5), as osteoporosis ⁽⁶⁾. However, not every person diagnosed with osteopenia will develop osteoporosis ⁽⁷⁾.

Renal osteodystrophy (ROD) is a spectrum of bone mineral changes that could range from the high-

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turnover lesions of secondary hyperparathyroidism to the low-turnover lesions of a dynamic bone disease. The impact of different types of ROD on bone density in patients with CKD remains undefined. Dual energy X-ray absorptiometry (DXA) is the commonest method used to screen for osteoporosis in adults due to its precision and accuracy, short scan time and low radiation (9).

Aerobic exercise increases bone mass by using body weight as the resistance. Walking and running are great ways to increase or maintain bone mass while increasing cardiovascular fitness. (9)

Exercise training in adults with CKD can affect the following factors: Muscular hypotrophy, strength, endurance & physical functioning (9,10). The structure and number of capillaries and mitochondria (11). Glucose meta-bolism (12). Aerobic capacity (13). Blood pressure (14) and Cardiac performance (11).

It is known that inactivity, muscle wasting and reduced physical functioning especially for those on long-term dialysis are associated with increased mortality in CKD. Exercise in patients receiving regular dialysis as a treatment for end-stage renal disease was first introduced 3 decades ago, but is still only offered in a minority of renal units around the world, despite a significant body of evidence to support its use. Work is needed to increase awareness of the potential benefits of increased physical activity for patients with advanced CKD (15).

This study was conducted to compare the effect of two different intensities of aerobic exercises on bone mass density in patients with haemodialysis.

II. SUBJECTS, MATERIALES AND METHODS

a) Subjects

Thirty male patients with mean age (52.75 ± 4.51) years were enrolled in this study; they underwent renal haemodialysis for 2 years ago with rate of 3 times/week. They were randomly selected from Police hospital using one to one base. All patients gave their written informed consent for the participation in the study that had been preceded by the explanation of the aim of the study and its course, their role in it with regard to time and money, assurance of protection of the obtained data, and information about free-willingness to participate in the study and the possibility to withdraw from the study at any time.

b) Inclusion criteria

- body mass index ranged from 25 to 29 kg/m².
- systolic blood pressure ranged between 130-190 mm Hg.
- diastolic blood pressure between 85-100 mm Hg).
- T- score between -1.1 and -2.4 SD according to DEXA measurements.
- Male subjects with age ranged from 45 to 55 years

c) Exclusion criteria

- chest, cardiac, or hepatic diseases.
- severe life limiting illness (e.g. malignancy).

- marked anaemia (Ht < 25%).
- using of weight-loss medications.
- smoking.
- neurological or other endocrinal disorders.
- Laboratory investigation kit.

d) Instrumentations

i. Evaluation tools

- RTZ-120 health scale was used to measure subject's weight
- Height scale
- 3-Body composition was assessed by dual-energy X-ray absorptiometry (DEXA) using a Lunar DPX-L densitometer. (Lunar Prodigy Bone Densitometer)

ii. Treatment tools

- Electronic treadmill and pulsometer were used to perform walking training program

e) Procedures

Evaluation: All patients were initially assessed for their weight, and height to calculate body mass index, heart rate and blood pressure.

The other 2 steps of evaluation were assessed at the beginning of the study and after 8 weeks of training: (a) Laboratory investigations (Before dialysis sessions), blood samples are collected by venipuncture for detecting the levels of Serum Calcium and Phosphorus. (b) A DEXA scanner was used for evaluation of BMD.

Subjects were placed in a supine position or on their side while the x-ray scanner performed a series of transverse scans, moving from top to bottom of the region being measured at 1-cm intervals. Three separate scans were performed:

- 1) AP view of the lumbar (L1-L4) spine.
- 2) AP view of the left hip providing information on the femur.
- 3) AP view of the left wrist with the subject supine.

While the scanner moved across the left hip, providing information on the femur neck (whole hip), left wrist (33% of left radius), and measure lateral view of the lumbar (L1-L4) spine. Regional and total body BMD measurements with this technique are highly reliable when subject positioning is carefully standardized (16).

The test results included the following scores: T score, Z score, Bone mineral density, Percentage, Age matched percentage.

f) Training program

Patients were randomly assigned into two groups of equal number, Group A and Group B (each group consists of fifteen patients) Patients were recruited two hours early prior to dialysis session. electronic treadmill and pulsometer were used to perform walking training program, with maximum Heart Rate (MHR) calculated according to (220-Age) for men.

Group A received a program of moderate intensity aerobic exercise (60%-70% MHR) with an exercise period of 40 minutes divided as warming up phase:3-5 min. with 30% MHR, actual phase:20-30 min. with 60%-70% MHR and cooling down phase:3-5 min. with 30% MHR three times weekly for six months.

period of 40 minutes divided as warming up phase : 3-5 min. with 30% MHR, actual phase: 20-30 min. with 40%-60% MHR and cooling down phase:3-5 min. with 30% MHR three times weekly for six month. The training program was performed under careful supervision for both groups.

Group B received a program of light intensity aerobic exercise (40%-60% MHR) with an exercise

III. RESULTS

Table 1 : Demographic characteristics of the patients in both groups (A&B)

Items	Group A		Group B		Comparison		S
	Mean	±SD	Mean	±SD	t-value	P-value	
Age (yrs)	51.86	±4.22	53.6	±4.82	1.04	0.3	NS
Weight (Kg)	86.26	±10.06	84.66	±7.37	0.49	0.62	NS
Height (cm)	172.26	±5.68	169.33	±6.97	1.26	0.21	NS
BMI (Kg/m ²)	29.02	±2.61	29.56	±2.53	0.57	0.57	NS
Systolic blood pressure (mmHg)	162.66	±17.91	165.33	±15.52	0.43	0.66	NS
Diastolic blood pressure (mmHg)	93.66	±5.49	91.66	±5.87	0.96	0.34	NS

Yrs: years, Kg.: Kilograms, Cm. centimeters, Kg/m²: Kilogram per meter square, mmHg: millimeters mercury

Table 2 : Statistical Analysis of Calcium levels pre and post treatment for both groups (A & B)

Calcium level	Group A		Group B		Between both groups	
	Pre	Post	Pre	Post	Post	post
Mean ± SD	7.97±0.72	8.95±0.61	8.03±0.5	8.38±0.52	0.06	0.57
t-value	7.5		3.02		0.26	2.75
P-value	0.0001*		0.009*		0.79	0.01*
Percentage of improvement	12.29 %		4.23 %			

SD: Standard Deviation, *: Significance

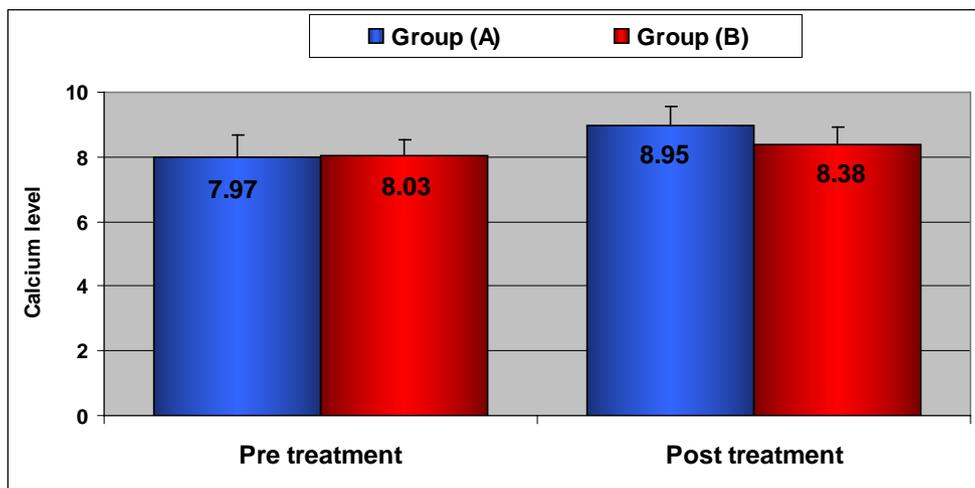


Figure 1 : Mean and ±SD of Calcium level pre and post treatment of groups (A,B)

Table 3 : Statistical Analysis of Phosphorus levels pre and post treatment for both groups (A & B)

Phosphorus level	Group A		Group B		Between both groups	
	Pre	Post	Pre	Post	Post	post
Mean ± SD	6.46±1.39	5.05±1.21	6.44±0.8	6.02±0.78	0.01	0.96
t-value	6.71		3.09		0.03	2.59
P-value	0.0001*		0.008*		0.97	0.01*
Percentage of improvement	21.67 %		6.52 %			

SD: Standard Deviation, *: Significance

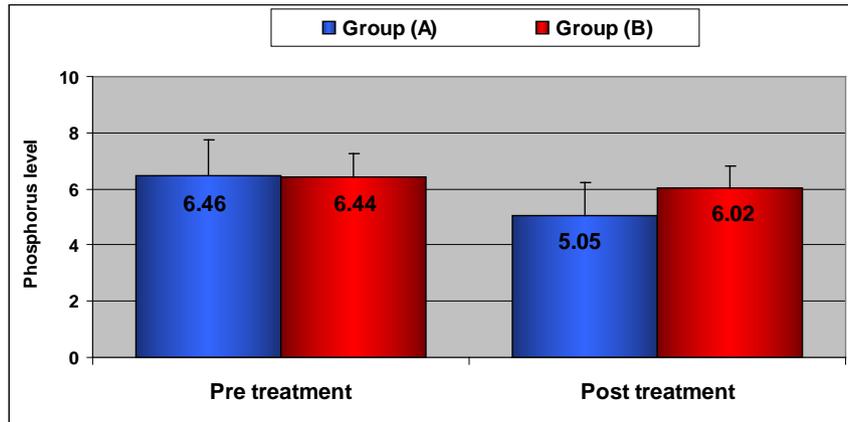


Figure 2 : Mean and ±SD of Phosphorus level pre and post treatment of groups (A,B)

Table 4 : Mean values of T score pre and post treatment at lumbar spine, left hip, left wrist for group A

Group A	pre exercise	Post exercise	T- value	P- value	Percentage of change
Lumbar spine	1.30 ± 0.747	1.10 ± 0.759	6.96	0.001*	18.2%
Left hip	1.36 ± 0.894	1.20 ± 0.928	6.07	0.001*	13.3%
Left wrist	1.40 ± 0.692	1.30 ± 0.776	7.22	0.001*	7.69%

*: Significance

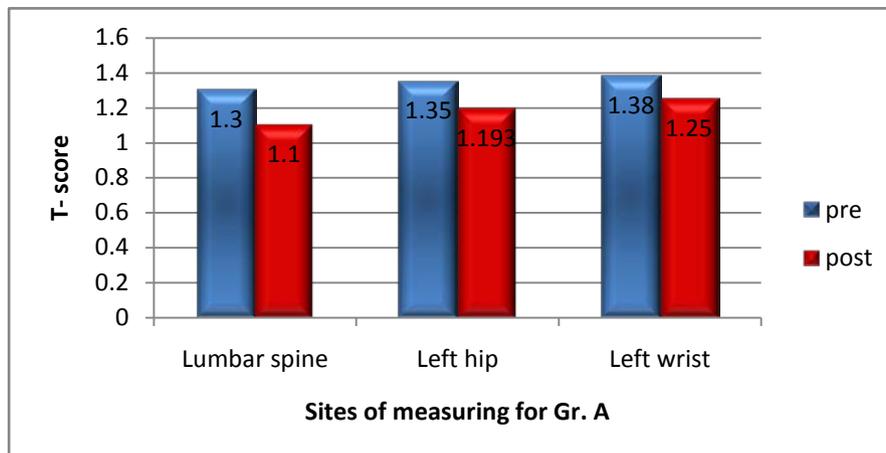


Figure 3 : The mean values of T score before and after exercise at lumbar spine, left hip, left wrist in group A.

Table 5 : Mean values of T score pre and post treatment at lumbar spine, left hip, left wrist for group B

Group B	Pre exercise	Post exercise	T- value	P- value	Percentage of change
Lumbar spine	2.17 ± 0.72	1.95 ± 0.90	6.96	0.001*	11.3%
Left hip	1.53 ± 0.91	1.50 ± 0.95	6.07	0.001*	2%
Left wrist	1.89 ± 1.0	1.87 ± 0.97	7.23	0.345	-----

*: Significance

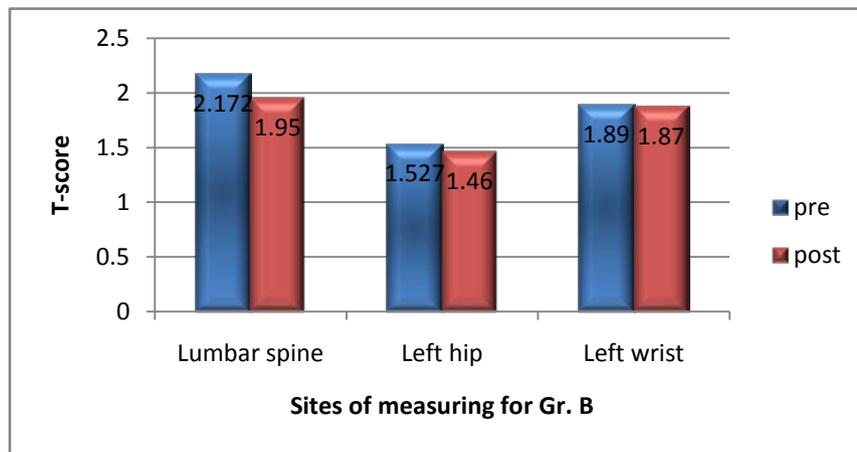


Figure 4 : The mean values of T score before and after exercise at lumbar spine, left hip, and left wrist in group B

Table 6 : Comparison between post treatment between both groups (A&B)

	Group A	Group B	T- value	P- value
Lumbar spine	1.95±0.82	1.10±0.75	-2.779	0.010*
Left hip	1.50±0.95	1.20±0.92	-0.735	.467
Left wrist	1.90±0.96	1.40±0.77	1.51	0.14

IV. DISCUSSION

Changes in calcium metabolism during exercise are dependent on the exercise intensity. Moderate endurance exercise increases serum calcium level (17) but decreases serum PTH (18). In bone, endurance exercise increases bone mineral density (BMD), bone strength (19) and bone formation rate (20). Thus, moderate endurance exercise seems to induce positive calcium balance, and has a beneficial effect on bone metabolism. In addition, a combination of moderate-impact exercise and adequate calcium intake can increase bone strength during childhood (21). Interestingly, modes of exercise, such as running (weight-bearing exercise) and swimming (non-weight-bearing exercise) can affect bone calcium metabolism in a different way.

It is established that physical activity before dialysis treatment increases urea Kt/V through improved perfusion of muscle, the main urea-containing body compartment. Similar effects have been described for phosphate removal with predialysis physical activity increasing phosphate removal by 6% and intradialytic activity even by 9% (22).

Even moderate exercise is related to an enhanced bone mineral density in peripubertal boys and also in young men compared to controls with a low level of physical activity. Animal studies have demonstrated that such an increase in bone mass is the result of an enhanced formation of organic bone matrix and a higher apposition rate of minerals such as calcium (Ca). A moderate level of physical exercise can already acutely influence various Ca metabolic parameters in untrained human subjects: Alterations can include a decrease in ionized serum Ca levels and an increase in serum parathyroid hormone (PTH) levels (23).

In the present study there were significant difference between the two groups (group A &B) in serum blood sample of calcium and phosphorus, as there were significant increase in groups (A& B) in serum calcium (12.29%, 4.23%) respectively, and significant decrease in serum phosphorus in group A compared to group B (21.67%, 6.52%) respectively in response to the designed aerobic exercise program.

As well as increased percent of improvement in T score for group A in the measured sites lumbar spine, left hip and left wrist by 18.2%,13.3% and 7.69% respectively. Regarding to group B the percent of improvement was less as shown in lumbar spine by 11.3% and left hip by 2% with no change in the left wrist. That dragged the emphasis to the effect of the moderate exercise applied to group A that gives significant increase in bone mineral density for patients on renal hemodialysis.

The results of the study after the suggested period of treatment confirmed the findings of John et al., 2007 (24) who stated that moderate exercise intensity results in regional increase in bone mass.

This Coincided with Asadi et al., 2007 (25) who studied the effects of exercise in reducing phosphorus levels and reported that although exercise decreased the level of phosphorus, the significant effects and changes could be observed in long-term and perhaps more intense exercise might be required for some patients.

The rehabilitation of the hemodialysis patients is enhanced, most likely because aerobic exercise induces elongation and an increase in the diameter of the striated muscle fibre, improves their capillary vasculature, as well as their aerobic capacity, and positively affects their blood pressure measurements, their brain function and the lipid profile. The increased ionic calci-

um of the cell sarcoplasm in the skeletal muscles, which is prevalent during the muscle contractions ⁽²⁶⁾

The results of numerous studies have shown that exercise training to be of benefit for dialysis patients⁽²⁷⁾ during haemodialysis on physical performance and nutrition assessment that agreed with results of this study. In addition to its well-known beneficial effects on cardiovascular fitness and mortality ⁽²⁸⁾ exercise also has an anabolic effect and has been shown to reduce muscular atrophy in dialysis patients ⁽²⁹⁾

The results of the present study showed significant improvement in calcium and phosphorus electrolytes with aerobic exercise during hemodialysis that coincided with the data presented by **Vaithilingam et al., 2004** ⁽²²⁾, who suggest that an aerobic exercise movement's regimen for 15 minutes during hemodialysis sessions improve serum phosphate and calcium levels in a period of 8 weeks. This observation might be due to direct beneficial effects of aerobic exercise or general effects of regular intradialytic exercise.

These findings agree with **Hagberg et al., 2001** ⁽³⁰⁾ who stated that prolonged low-to-moderate-intensity physical activity was associated with higher BMD.

The results supports the findings of **Vencint and Braith, 2002** ⁽³¹⁾ who reported that, regional BMD can be increased via high-intensity resistance exercise even in healthy elderly persons. The results also indicate that both high- and low-intensity resistance exercises can change biochemical indices of bone turnover. As evidenced by increased OC/PYD and BAP/PYD ratios, these changes seemingly favor increased bone formation.

The results of this study are also consistent with that stated by **Hurley and Stephen, 2000** ⁽³²⁾ who reported that strength training is considered a promising intervention for reversing the loss of muscle function and the deterioration of muscle structure that is associated with advanced age as well as osteoporotic effects due to renal dialysis. This reversal is thought to result in improvements in function abilities and health status in patients on dialysis by increasing muscle mass, strength and power and by increasing bone mineral density (BM-D).

V. CONCLUSION

The results of this study supported the good effect of aerobic exercise on serum calcium and phosphorus in patients under renal hemodialysis. Aerobic exercise showed a significant increase serum calcium and significant decrease serum phosphorus in both groups in addition to increased BMD. The result of this study concluded that moderate intensity aerobic exercise (60%-70%MHR) is beneficial than light intensity aerobic exercise (40%-60%MHR) in modulating serum calcium and phosphorus in hemodialytic patients reflected on BMD.

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