"The effect of Exercise during hemodialysis on serum levels of Albumin, calcium, phosphorus and parathyroid hormone: a randomized clinical trial"

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Research Article

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Abstract

Background: Chronic kidney disease is often accompanied by disturbances in the levels of serum electrolytes. Because of electrolyte imbalance and other factors, the patients experience some of the systemic symptoms and physical and mental dysfunction. We aimed determine the impact of exercise during hemodialysis on serum levels of Albumin, calcium, phosphorus and parathyroid hormone.

Methods: In a randomized controlled trial in hemodialysis units of Iran's two hospital, 60 patients undergoing hemodialysis having required criteria were included and assigned into the exercise group (n = 30) and the control group (n = 30). An exercise program using stationary bicycles were done in the intervention group, 60 minutes/ every session, three times a week, for 8 weeks. The main outcome measures were the serum levels of Albumin, Calcium, Phosphate, and Parathyroid hormone.

Results: The independent t-test results showed no significant difference between the mean serum levels of Albumin, Calcium, Phosphorus and Parathyroid hormone before the intervention (P > 0.05). However, after an eight-week intervention, significant improvements were seen in serum phosphate levels and Parathyroid hormone (P=0.04), while the serum levels of Albumin (P=0.3) and calcium (P = 0. 5) did not change significantly in the intervention group.

Conclusions: An exercise program by stationary bicycles is a safe, effective and complementary clinical intervention in patients with ESRD on hemodialysis.

Trial registration: The clinical trial was found to be in accordance to the ethical principles and the national norms and standards for conducting medical research in Iran. IRCT registration number: IRCT20150116020675N4. Registration date: 01/09/2020

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Keywords: Exercise, Hemodialysis, Albumin, calcium, phosphorus and parathyroid hormone

Background

Chronic kidney disease is considered a public health problem and in the world about 50 million people are suffering from it. a high percentage of these are needed to hemodialysis as a replacement treatment [1]. According to the United States Renal Data System, the number of patients suffering from end-stage renal diseases (ESRD) increases each year and more than 320 000 American patients with ESRD are under treatment with hemodialysis [2]. in many other countries, the high incidence and prevalence has reported. About 91.9% of patients with ESRD need to receive hemodialysis treatment as renal replacement therapy [3]. Hemodialysis using low-flux membranes is not able to remove sufficiently middle molecules. Longer dialysis time and use of high-flux membranes did not improve clinical outcome. Albumin loss is another concern in the patients.

Anorexia, insufficient intake of nutrients, nutrient losses during hemodialysis, and elevated protein catabolism contribute to nutritional deficits and hypoalbuminemia in patients undergoing dialysis [4]. In the patients, hypoalbuminemia is a strong predictor of poor outcome and mortality. Therefore, it is important to do interventions for improving levels of albumin in the patients [5].

One of most common electrolyte disorders in patients undergoing dialysis is disturbance of calcium and phosphate, which contributes to the development of hyperparathyroidism. Higher levels of serum phosphorus, calcium–phosphorus and parathyroid hormone (PTH) emerge as important clinical issues in dialysis patients. These electrolyte disorders are associated with increased risk of osteodystrophy, vascular

calcification and cardiovascular diseases in the patients. [6]. Calcium supplementation, dietary phosphorus restriction, phosphate-binding agents, and treatment with vitamin D are considered as the most common treatments used to correct the serum levels of calcium and phosphorus, which result in various complications and side effects. Thus, finding more effective treatments to improve these electrolyte disorders is necessary [7,8].

One of the treatments is exercise that can help to maintain electrolyte balance, improvement of mental and physical function and the quality of life of patients undergoing hemodialysis. Results of a study on exercise in hemodialysis patients suggest that exercise could decrease serum levels of Phosphate in the patients, but it did not have significant effect on serum calcium of the patients [3]. Another study also presents that hyperphosphatemia in the patients can be improved by exercise [9]. On the other hand, a study by Paluchamy et al. (2018) showed that an exercise program can improve both serum levels of Phosphorous and Calcium in patients [10]. Tayebi et al (2018) also showed that exercise during hemodialysis could be beneficial for improving the albumin levels in hemodialysis patients [11]. In this study, we aimed to implement exercise during hemodialysis for examination its effects on serum levels calcium, phosphorus and parathyroid hormone, through a randomized controlled trial, and our hypothesis is that exercise can improve the serum electrolytes in this patient population.

Methods

This randomized controlled trial (two-group, two-stage) was conducted in the dialysis wards of two hospitals located in Isfahan, Iran, Noor and Al-Zahra hospitals. 60 ESRD patients undergoing hemodialysis, who were eligible to be included in the study, consented to participate in this study.

Sampling was performed randomly and in the first meeting the purpose of the research was explained and informed consent was obtained from the patients. Then, using simple randomization, the 60 patients were allocated to two groups, intervention (n = 30) and control (n = 30), so that the two groups of patients did not see each other.

Inclusion criteria

Patients were receiving hemodialysis 3 times per week, 3 to 4 hours per treatment. Patients aged ranging from 18 to 65 years, the patients were on hemodialysis for more than 3 months. None of them did not have problems mentioned below: a history of parotidectomy surgery, ischemic heart diseases, myocardial infarction, angina, acute pulmonary disease so that the patient needs oxygen therapy during dialysis and stroke or transient ischemic attacks during the last 3 months and also physical that prevent the patient from exercising

Exclusion criteria

the presence of diseases including cardiovascular and pulmonary diseases, musculoskeletal disorders which may prevent the patient from doing the exercise program. Also, patients who did not do the exercises for three consecutive sessions and six non-consecutive sessions and also those who were reluctant to participate were excluded from the study.

Data collection

Serum levels of Albumin, calcium, phosphorus and parathyroid hormone were measured with blood samples before and after the intervention. The blood samples were drawn by the ward nurses and then the samples were delivered to the hospital lab for analysis.

Intervention

The method of performing the intervention is based on the study by Dashtidehkordi et al. (2019) [12]. The duration of the intervention was 8 weeks. the exercise program was carried out after 30 minutes after starting hemodialysis treatment, one hour / every session with five-minute intervals, 3 times a week, during the dialysis. The exercise program was performed using a stationary bicycle (Mini-bike made in Taiwan).

The intensity of the exercise was chosen by the patient based on the rotational speed of the bike. The minimum rotational speed of the Mini-bike was set at 15 rpm but the patient could increase it based on their tolerance. Before the intervention and also at the rest intervals, blood pressure of the patients was. During the intervention, If the patients had a systolic blood pressure of 180 mmHg and higher and or lower than 90 mmHg, chest pain and shortness of breath during dialysis, the exercise was stopped. In addition, the patients were taught to stop the Mini-bike and notify the researcher if they felt any dizziness, exhaustion, headache, palpitations, nausea and any other adverse effects. for the patients of the control group participated in an exercise program, including 10 stretching exercises (any exercises for 30 s and 1 min rest between them). At the end of 8nd week of the intervention, the blood samples were taken and then were delivered to the hospital lab for analysis.

Statistical tests

The IBM SPSS Statistics 19 software was used to analyze the data obtained. To compare qualitative variables, including gender, chronic medical conditions and occupational status, the Chi-square test was used (Table 1). The independent t-test was used to compare quantitative variables, including age, time on dialysis (years), and also the means of serum levels of Albumin, Calcium, Phosphorus and Parathyroid hormone between the intervention and control groups. The paired samples t-test

was used to compare means of serum levels of the variables in each group (Table 2). The minimum significant level was 0.05.

Results

Basic demographic data and the clinical characteristics of the studied participants are shown in Table 1. Out of the 60 patients, 54 patients completed the study period with all the assessments. Of the 30 patients in each group, 3 patients were excluded. (Fig. 1). There were no significant differences between the two groups based on demographic and clinical characteristics in the pre-test ($P < 0.05$). (Table 1). There were also no significant differences between the two groups based on serum levels of Albumin, Calcium, Phosphorus and parathyroid in the pre-test. There was a significant difference between the groups after the intervention in serum levels of Phosphorus and parathyroid hormone ($p < 0.05$). However, there was no significant difference between the two groups based on serum levels of Calcium and Albumin in the post-test. This difference, however, was not significant in the control group ($p > 0.05$) (Table 2). The Table 3 shows the comparison of difference serum levels the variables before and after the intervention in the groups.

Discussion

The results of the present study showed that exercise during hemodialysis, by using stationary bicycle, can significantly improve serum levels some serum electrolytes, including serum levels of phosphate and parathyroid hormone, that can be beneficial for patients. However, significant improvement was not seen on the serum levels of other electrolytes including Albumin and calcium. In the control group, the stretching exercises had no significant effect on the patients.

The results were consistent with the study by Makhlough et al. (2012) who reported that a simplified exercise program can improve serum levels

of phosphate, but have had no significant effect on improving serum levels of Calcium [3]. The results are also in line with the results of the study conducted by Salhab et al. (2019), where they showed that exercise during dialysis could be beneficial for hyperphosphatemic patients under hemidialysis [9]. Vaithilingam et al. (2003), however, showed that exercises during hemodialysis could decrease serum levels phosphate, but the decline was not significant; these authors, however, mentioned that although exercise decreased the level of phosphorus, the significant decrease could be observed in long-term and perhaps more intense exercise might be needed for some patients [13]. The results are also consistent with the results of the study conducted by Nesreen et al. (2013), where they showed that Changes in calcium metabolism during exercise are dependent on the intensity of exercise. Moderate endurance exercise (an exercise period of 40 minutes) increases serum calcium level but decreases serum parathyroid hormone [14]. However, the results of the present study are not in line with the results of study conducted by Paluchamy et al. (2018) that showed an intradialytic exercise program can improve serum levels of both Phosphorous and Calcium [10]. the results of the present study also are not consistent with the results of the study by Lio et al. (2016), investigating the impact of intradialytic aerobic cycling exercise on improving bone density in hemodialysis patients, which showed the exercise had no significant effect on improving serum levels of Calcium and parathyroid hormone in the patients, but it could increase serum levels of Albumin [15]. However, In the present study, no evidence was found suggesting the effect of exercise on patient's levels of Albumin in the intervention group compared with the control group. Such inconsistencies might be attributed to the difference in the duration of the intervention (a three-month program) and different exercises (a 5-minute warm-up, 20 minutes of cycling at the desired workload, and a 5-minute cool down). On the other hand, the present's results are in line with the

results obtained by Tayebi et al. (2018) who showed that exercise during hemodialysis had no significant effect on serum levels of Albumin in intervention group [11]. The results of the present study are not in line with the results the study by Watanabe et al (2021), that showed home-based exercise could not significantly affect serum levels of Albumin, Calcium and phosphate [16]. The reason for this difference is maybe the use of different intervention methods and the difference in the duration of the exercise (6 months compared to 8 weeks). The small sample size and relatively short duration of follow-up might be considered as limitations to generalizing the findings of this study. Therefore, the performance of similar studies with larger sample sizes and longer periods of follow-up is recommended. On the other hand, In the present study, the intensity of exercise for each patient was not measured. Therefore, it is suggested that future researchers consider this element too

Conclusions

the results of this study showed that exercise during hemodialysis can improve serum levels of some electrolytes including phosphorus and parathyroid hormone in these patients. Thus, nurses can use it to decrease electrolyte imbalances that occur in chronic renal failure and to improve general health of the patients.

Abbreviations

ESRD: End-Stage Renal Disease, PTH: Parathyroid hormone

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Availability of data and materials
The data of the current study are available from the corresponding author on reasonable request.

Authors' contributions
AD carried out data collection, and measurement, statistical analysis, interpretation of results and wrote the manuscript. He participated in collecting data and reviewed medical records.
NS participated in reviewing medical records, the study design and coordination as well as managing the research project. All authors read and approved the final version prior to submission.
JS helped in collecting data.

Ethics approval and consent to participate
The clinical trial was found to be in accordance to the ethical principles and the national norms and standards for conducting medical research in Iran. This research was approved by the Ethics Committee of Isfahan University of Medical Sciences No. IR.MUI.MED.REC.1399.212, Approval Date: 07-06-2020. The clinical trial was also found to be in accordance to the ethical principles and the national norms and standards for conducting medical research in Iran. IRCT registration number: IRCT20150116020675N4. Registration date: 01/09/2020. The purpose of the research was explained for participants in the study and written informed consent was obtained from them.

Consent for publication

Not applicable**.**

Competing interests

The authors declare that they have no competing interests**.**

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Table 1 Comparison of demographic variables between the two groups

Variables		Control group		Intervention group		P value
		Number or Mean	Percent	Number	Percent	
Sex	Female	24		23		0.61
	Man	3		4		
Employment status	Employed	9		12		0.1
	Unemployed& Retired	18		15		
Other diseases	To have	23	22			0.15
	Not to have	4	5			
Age	Average age (Year)	55.3		49.9		0.1
The number of months of treatment with dialysis	Average years of treatment with dialysis	4.5		5.6		0.34

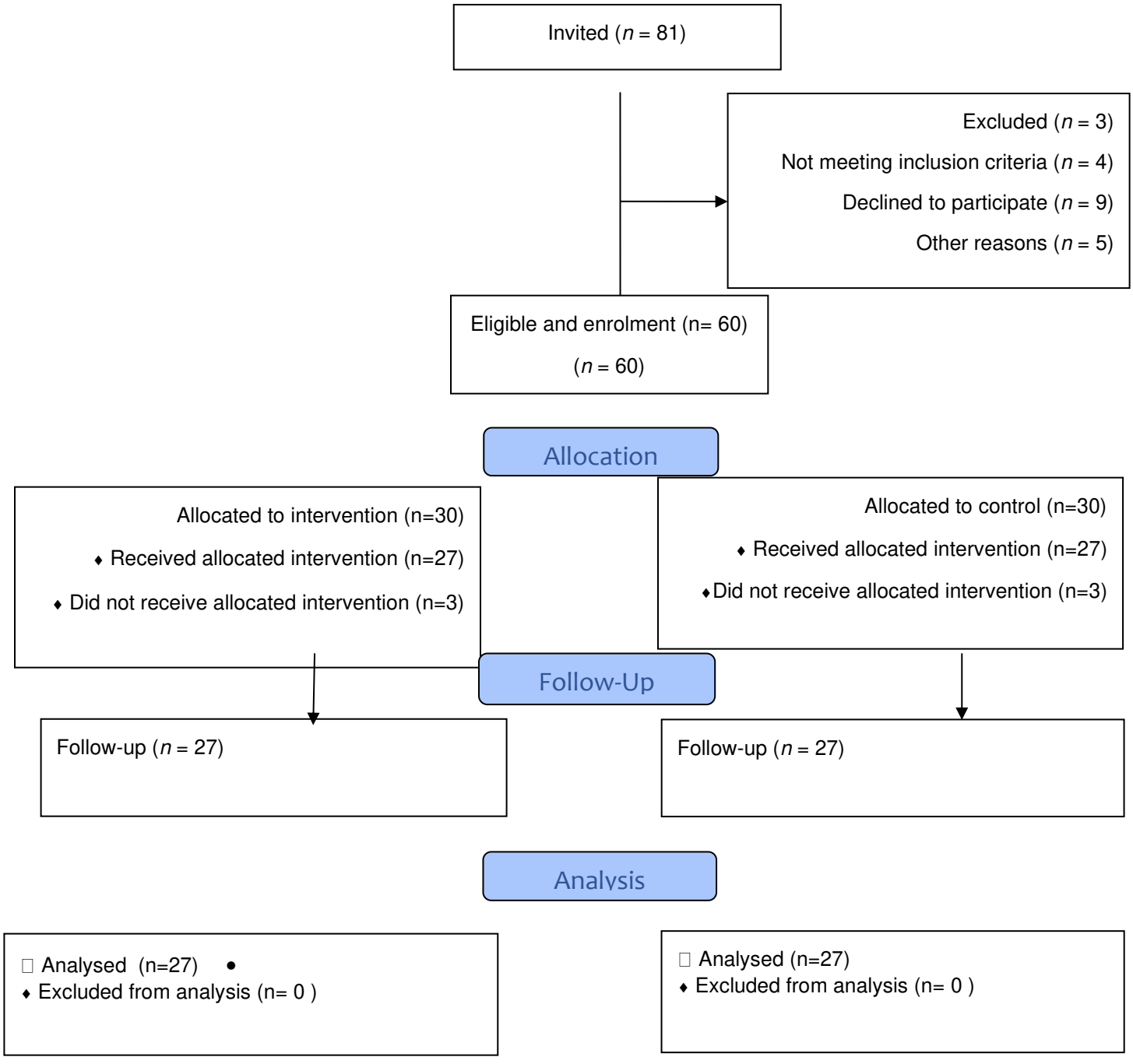
Table 2 Comparison of serum levels of electrolytes before and after the intervention in the intervention and control groups

Variables	Times	Intervention group		Control group		T	P value
		Mean	SD	Mean	SD		
Albumin	Before intervention	3.87	0.4	3.98	0.4	1.04	0.3
	After intervention	4.03	0.33	3.8	0.54	-1.6	0.1
	P value	0.1		0.17			
	t	-1.72		1.4			
calcium	Before intervention	8.37	0.72	8.57	0.57	1.09	0.28
	After intervention	8.53	0.56	8.6	.42	.68	0.5
	P value	0.14		0.37			
	t	-1.52		-0.9			
phosphorus	Before intervention	5.08	1.01	4.91	0.1	-0.6	0.55
	After intervention	4.6	1.2	5.2	0.78	2.1	0.044
	P value	0.01		0.22			
	t	2.6		-1.3			
parathyroid hormone	Before intervention	470.33	315.4	456.5	334.3	-0.16	0.88
	After intervention	342.2	242.8	486.2	261.5	2.1	0.041
	P value	0.003		0.47			
	t	3.33		-0.73			

Table 3 Comparison of average difference of serum levels of electrolytes before and after the intervention in both groups

variables	Intervention group		Control group		t	p
	Mean	SD	Mean	SD		
Albumin	0.03	0.52	0.18	0.56	1.5	0.15
calcium	0.14	0.57	0.18	0.87	0.24	0.8
phosphorus	0.48	0.95	0.28	1.0	2.9	0.006
parathyroid hormone	128.1	200	30	210	2.8	0.007

Fig. 1 Participant flow and follow up



Figures

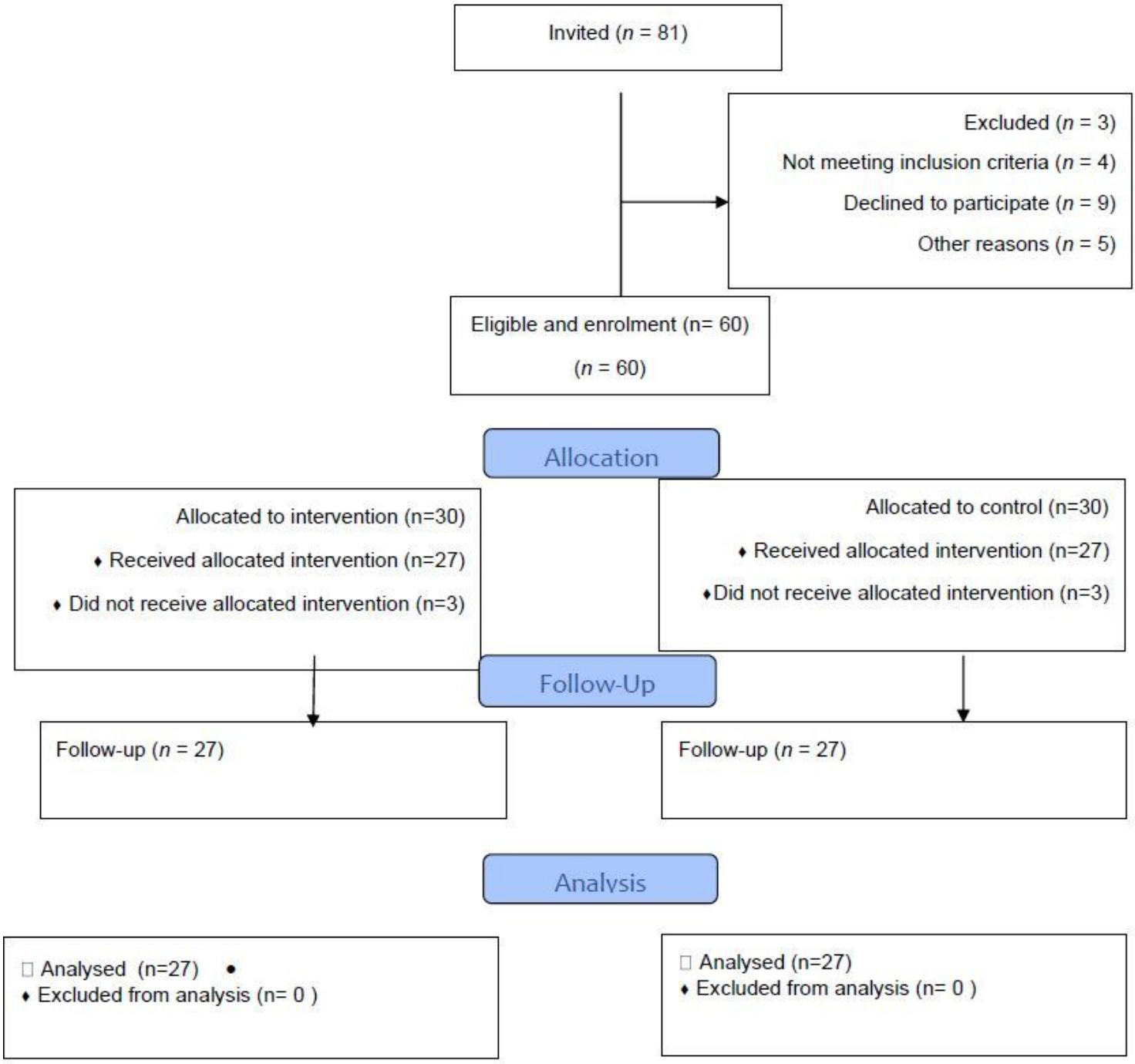


Figure 1

Participant flow and follow up