Effect of 8 Weeks of Vitamin D Supplementation and Water-Based Exercise on Cardiometabolic Profile in Women With Type 2 Diabetes

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Abstract

Background

Since type 2 diabetes is the most common metabolic disease, it is necessary to know the factors affecting on the complications of this disease. The aim of this study was to investigate the Effect of 8 weeks of vitamin D supplementation and water exercise on cardiometabolic profile in women with type 2 diabetes.

Methods

40 women with type 2 diabetes participated in this study voluntarily and randomly divided to four groups: 1) vitamin D+ water exercise, 2) vitamin D, 3) water exercise, and 4) control groups. Water exercise groups (groups 1 and 3) performed 3 sessions of water training per week during 8 weeks (15 minutes of warm-up, 45 to 60 minutes of main activity with a Borg scale of 14 and 10 minutes of cooling). Vitamin D groups (groups 1 and 2) received 50,000 (IU) vitamin D supplements once a week. Levels of fasting blood sugar (FBS), insulin, hemoglobin A1c (HbA1c), C- reactive protein (CRP) levels, as well as lipid protein profile (triglyceride, total cholesterol, high and low density lipoproteins (LDL and HDL)) were measured before and after intervention. Insulin resistance was also obtained by calculating HOMA-IR.

Results

Weight, waist circumference, and body fat mass were significantly decrease after intervention in Vitamin D+ water exercise group (P= 0.001, 0.001, 0.032, and 0.013 respectively), as well as CRP, glycemic and lipid profile were significantly improved after intervention in water exercise group.

Conclusion

The results of the present study showed that water exercise plus vitamin D supplementation had synergism beneficial effects on anthropometric indices and cardiometabolic status of type 2 diabetic patients and can be used as a non-pharmacological and non-invasive method to reduce complications of type 2 diabetes.

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Background

Type 2 diabetes or Diabetes mellitus is currently the fourth leading cause of non-communicable diseases in the world, which is closely related to the obesity epidemic [1]. This disease is a chronic condition in which insulin resistance and impaired insulin secretion play a major role in its pathogenesis [2]. Insulin resistance is known to be the most important factor in the progression of type 2 diabetes and the associated complications, which is defined by a decrease in the optimal function of muscle cells to absorb glucose in response to insulin secreted by pancreatic beta cells [3]. Type 2 diabetes can have serious side effects, including high blood sugar, hypertension, vision damage, and kidney failure. If left untreated, it can lead to stroke, blindness, amputation and lower limb amputation [1]. This metabolic disorder can also endanger a person's quality of life and impose a heavy economic burden on health systems [4].

A regular exercise program plays an important role in the treatment and control of diabetes, as well as, can improve insulin resistance [5, 6]. Among all type exercise program, recent studies show that aquatic exercise is associated with a reduced risk of inflammatory diseases, atherosclerosis, obesity, and renal function [7-9]. These exercises have significant effects on health and weight control [10]. In addition, water exercise is an appropriate alternative for the elderly who have mobility problems, pain and imbalance [11].

Vitamin D deficiency is a common nutritional risk factor in the worldwide that is associated with increased insulin resistance. In recent years, vitamin D has been suggested as an important factor in improving diabetes and its complications [12, 13]. Elevated serum levels of vitamin D have also been reported to help maintain glucose homeostasis by increasing insulin sensitivity, and may stimulate insulin secretion by pancreatic beta cells, thereby increasing glucose tolerance [14, 15]. However, some studies have not clearly confirmed the positive effects of vitamin D supplementation on glycemic index, insulin sensitivity, and glucose homeostasis [16, 17].

According to studies on the relationship between vitamin D supplementation and water exercise in people with type 2 diabetes, these interventions seem to have beneficial effects, although in most of these studies these factors have been assessed separately. Therefore, the purpose of the present study was to evaluate the effect of 8 weeks of vitamin D supplementation and water exercise on cardiometabolic profile in women with type 2 diabetes.

Materials And Methods

Study design

This randomized clinical trial was aimed to evaluate the effect of 8 weeks of vitamin D supplementation and water exercise on glycemic indices, lipid profile, and C- reactive protein (CRP) in women with type 2 diabetes. The sample size was determined based on the CRP level of the previous study [18] 10 participants for each group with 95% power and 5% significance. We considered 12 participants for each group due to a possible drop. The trial was ethically approved by the Ethics Committee of Kermanshah University of Medical Sciences (Ethical NO: IR.KUMS.REC.1397.656) and registered with the Iranian Clinical Trials Registry (registration number: IRCT20201223049811N1), data of registration: 12.01.2021; https://en.irct.ir/trial/53230. Written informed consent was obtained from all participants.

Participants, recruitment, and randomization

This current study was designed based on CONSORT statement for randomized clinical trials [19]. The study participants were recruited from diabetes clinic of Taleghani hospital, Kermanshah province, western Iran. Inclusion criteria were 40-60 year-old women with type 2 diabetes, no smoking, no cardiovascular disease, musculoskeletal disorders, rheumatoid arthritis, no fear of water, no supplements, especially vitamin D supplementation, and no diet in 6 months ago. Participants who were absent for more than one training session were excluded from the study, as well as, any physical injury during training, and inability to continue the training program were excluded from the study.

To assign participants to intervention or control group was applied simple random method. Using random numbers table, each participant will be assigned a number and selected randomly. Ultimately, 48 participants were assigned to four groups including: Vitamin D+ water exercise group (n=12), water exercise group (n=12), Vitamin D group (n=12), and control group (n=12). **(Figure 1)** The participants were completely unaware of the group they were in, therefore, they were in the same mental state.

Intervention

Water exercise group did your exercises in water during 8 weeks and every week for three sessions (24 sessions in total). Each session began from 9 to 10 in the morning for one hour in shallow part (80-120 cm) of the pool of Razi University in Kermanshah, Iran. Each water training session had three stages: the first stage, adapting to the water environment and warming up (15 minutes) including stretching movements in all joints and major muscle groups, walking forward, backward, sideways, on the heel and toe, and Jagging was in the water. The second phase of the exercise (30 minutes) included weight transfer from front to back, brisk walking in the water, sideways walking, and squats. The third stage was stretching, deep breathing and floating exercises (15 minutes). The intensity of the exercises was controlled using the Borg scale. To determine this scale, guide sheets are attached to the wall of the pool and the participants have already been trained. All exercises were performed in the indoor pool of Razi University with water temperature between 26-28 ° C. Vitamin D+ water exercise group was given vitamin D supplement (1 pearl 50000 IU Vitamin D made by Zahravi Pharmaceutical Company- Iran) weekly in addition to the mentioned exercises. Also, vitamin D group was received the vitamin D supplement (1 pearl 50000 IU Vitamin D made by Zahravi Pharmaceutical Company- Iran) weekly for 8 weeks. In total, each participant consumed 8 pearl vitamin D for two months. The control group performed only their daily activities during the study and no received the study supplement and no did the water exercise. All participant were asked to follow their usual diet, avoid from taking other supplements and physical activity during the study.

Demographic information

Demographic information and medical history of these participants were collected and recorded. These information included age, educational level, marital status, daily exposure to sunlight and medical history.

Anthropometric indices

Height was measured using standard wall-mounted stadiometer ((DETECTO, Model 3PHTROD-WM, USA) standing position without shoes with a precision of 0.1 cm. Weight was measured by (Seca, Germany) with the least clothing and without shoes. Body mass index (BMI) was calculated by dividing weight in kg by height square in meter. The non-stretched and flexible tape was applied to measure waist circumference in standing position at the level of the iliac crest at the beginning and end of the intervention [20]. Subcutaneous fat thickness of the subjects was obtained using a caliper (Lafayette skinfold caliper, Model 01127A, USA) at three points on the triceps, under the scapula and the right leg, and by substituting the numbers obtained in the Jackson and Pollack equation of three points, the body fat mass (BFM) was calculated. In addition to anthropometric indices, a calibrated digital brachial sphygmomanometer (Beurer BM26, Germany) we used to measure systolic and diastolic blood pressure (SBP and DBP) after at least 4-5 minutes of rest in sitting position.

Biochemical indices

From each participant, blood venous samples (10ml) were obtained after an overnight (10 to 12 hours) fast at the before and after the study. The blood samples were centrifuged, and serum was stored at -80 °C until analysis. Enzymatic method was used to analysis fasting blood sugar (FBS). Serum insulin was measured using ELISA kits (French company Diaclone, French) with a sensitivity of 0.179 μN. Glycated haemoglobin (HbA_{1C}) was analyzed by Ion exchange chromatography. Insulin resistance was determined based on the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) following formula:

HOMAIR = fasting blood sugar (mg/dl) × fasting insulin (micro U/ml)/ 405 [21].

Lipid profiles including total cholesterol (TC), high-density lipoproteins (HDL) and triglyceride (TG) concentration were measured by enzymatic kits (Pars Azmoon, Iran). LDL-cholesterol value was calculated by applying [22]. Vitamin D status based on serum levels of 25 (OH) D3 was detected by Electrochemiluminescence (ECL) method. CRP was also measured by turbidometry method. The basis of the turbidometric method is based on the formation of a complex resulting from the reaction between hs-CRP and its specific antiserum.

Dietary intake

At the beginning and end of this study, self- reported three-day food record questionnaire was received to assess the energy and nutrient intake (two days of week and the weekend) at the first and after eight week of the study. The amounts of energy and nutrients of their food intake were calculated by NUTRITIONIST 4 software using the United States Department of Agriculture Food Composition Table, which was modified for Iranian foods [23]. All data processing and entry were done by a trained dietitian.

Physical activity

The International Physical Activity Questionnaire (IPAQ) short form was applied to assess physical activity level. Total metabolic equivalent task (MET) per hour per week was calculated based on the instrument existed in the questionnaire. The validity and reliability of the questionnaire had previously been confirmed in Iran [24].

Statistical analysis

All statistical analyses were performed by SPSS software (version 23; SPSS Inc., Chicago, IL). In this study, descriptive statistics were used to describe the variables. In descriptive statistics, means, standard deviations (SD), and frequency percent were used to describe the findings. The normal distribution of quantitative data was determined by Kolmogorov-Smirnov test and the homogeneity of variances was assessed using the Leuven test. Chi-square test was used to compare qualitative variables. Two-way ANOVA was used to examine the differences between the variables before and after the intervention. Paired samples t-test was used to analyze within-group changes. P-values less than 0.05 were considered significant.

Results

In the present study, 48 participants were included to this intervention in which eight of them were excluded during the period of intervention due to excessive absenteeism in practice sessions (n=2), injury (n=2), unwillingness to continue cooperation (n=2), and some of them participate in the regular sports activities and go to the club (n=2). **(Figure 1)** Overall, 40 participants (10 participants in each of the studied groups including: Vitamin D + water exercise group, water exercise group, Vitamin D group, and control group) completed intervention period of the study. Basic demographic characteristics including age, marital status, education, and physical activity had no differences among four studied groups (P= 0.33, 0.43, 0.78, and 0.37 respectively). Baseline characteristics of the participants are presented in **Table 1**.

No statistically significant differences in energy and nutrient intake (protein, carbohydrates, and fat) were observed either within or between groups before and after the intervention. **(Table 2)**

Mean of weight, BMI, WC, and BFM were significantly decrease after intervention in Vitamin D+ water exercise group (P= 0.001, 0.001, 0.032, and 0.013 respectively), as well as weight and BFM were significantly decrease after intervention in water exercise group (P= 0.031 and 0.001). **(Table 3)**

As shown in **table 4**, glycemic indices including FBS, HbA_{1C}, insulin, and HOMA-IR significantly improved after Vitamin D and water exercise intervention. Also, lipid profile including TG, total cholesterol, and LDL, as well as, CRP was significantly decreased, whereas HDL level was increased after Vitamin D and water exercise intervention. **(Table 4)**

In addition, glycemic indices including HbA_{1C}, insulin, and HOMA-IR and lipid profile was significantly improved after water exercise intervention. While no changes were found after intervention in another two studied groups (Vitamin D and control groups) **(Table 4)**

Discussion

This current trial highlighted that water exercise plus vitamin D supplementation can improved anthropometric indices, glycemic and lipid profile. Furthermore, we found that water exercise alone also had beneficial effects on these mentioned conditions. However, intervention with vitamin D alone could decrease BMI, BFM, and HbA1c in these women with type two diabetes. Type 2 diabetes has become a global health problem. That is why efforts are being made to find innovative approaches to the prevention and treatment of diabetes. Proper physical activity guidelines for people with type 2 diabetes suggests a combination of aerobic and resistance training for optimal blood sugar control. On the other hand, with age, the prevalence of musculoskeletal disorders has increased, therefore, it is recommended to replace water exercise with aerobic and resistance training [25]. To best our knowledge, this current study was investigated effect of 8 weeks of vitamin D supplementation and water exercise on cardiometabolic profile in women with type 2 diabetes.

Our finding reflected that water exercise plus vitamin D supplementation had synergism beneficial effects on cardiometabolic profile in women with type 2 diabetes. Intervention with water exercise plus vitamin D lead to significantly decrease weight, BMI, WC, and BFM. In trial by Lim et al. [26] reported that after 12 weeks aquatic exercise in elder women, anthropometric indices such as weight, BMI, WC, and BFM significantly decreased and free fat mass significantly increased. In present study observed that positive changes in glycemic and lipid profile, as well as, CRP significantly decreased after 12 weeks intervention with water exercise plus vitamin D. These changes were significantly higher compared to another three studied groups. A systematic review by Delevatti et al. [27] on ten clinical trial studies showed that glycemic and lipid profile improved after different types of exercising in water. Jordan L. Rees et al. [25] in a meta-analysis on nine studies observed that the HbA1c decreased after 12 weeks water exercise. Exercise increases the number of GLUT-4 proteins that can decreases fasting blood sugar and ultimately decreases insulin resistance [28]. Water exercise is a very important part of sports activities that with its beneficial effects on increasing muscle mass can lead to an increase in basal metabolic rate and consequently weight control [29-31]. More muscle is involved in these exercises and can increase the dynamic pressure on the bones and muscles and increase glucose burning [29, 32].

On the other hand, results from the Vitamin D and Type 2 Diabetes (D2d) Study showed that Vitamin D supplementation and keeping serum levels within the desired range is an appropriate approach to prevent diabetes [33]. Vitamin D is a fat-soluble vitamin that is supplied through supplementation and skin biosynthesis, and food sources are poor in this vitamin. There are several factors that reduce the serum level of 25 (OH) D3 that can increase the risk of diabetes [34]. Overweight and obesity increase the risk of type 2 diabetes and decrease serum levels of 25 (OH) D3. On the other hand, proper physical activity and maintenance of BMI in the normal range play a role in increasing biosynthesis and absorption of vitamin D and increase serum levels of this vitamin [34, 35]. Another effective mechanism is the optimal intake of vitamin D on increased insulin sensitivity and secretion [36, 37]. Vitamin D deficiency is also associated with increased secretion of inflammatory cytokines, which potentially have undesirable effects on pancreatic beta cell function and lead to the development of diabetes [37].

Restrictions on exercise in older women should not be overlooked, and exercise in water is an effective strategy in improving the cardiometabolic status of these individuals. In addition, water exercises can help reduce musculoskeletal pain [38]. Water exercise in diabetics becomes even more important when considering the limitations and problems of exercise on land, such as skin problems, foot ulcers, double pressure on the joints of the body, and imbalance. From this perspective, water exercise has a potential benefit for elderly diabetics [39].

Limitations

The present study suffers from several limitations. First, the sample size and duration of our intervention were small and the findings should be interpreted with caution. Also, the control group was not completely sedentary and had their daily activities. Because it was morally impossible to advise all groups not to engage in any activity.

Conclusion

In conclusion, this current study reflected that water exercise plus vitamin D supplementation had synergism effects on improving anthropometric indices, glycemic and lipid profile. Furthermore, water exercise and vitamin D separately had beneficial effects on these mentioned conditions.

Abbreviations

Body fat mass (BFM); body mass index (BMI); C- reactive protein (CRP); Electrochemiluminescence (ECL); fasting blood sugar (FBS); Glycated haemoglobin (HbA_{1C}); high-density lipoproteins (HDL); Homeostatic Model Assessment for Insulin Resistance (HOMA-IR); international physical activity questionnaire (IPAQ); systolic and diastolic blood pressure (SBP and DBP); standard deviations (SD); total metabolic equivalent task (MET); total cholesterol (TC); triglyceride (TG)

Declarations

Ethics approval and consent to participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Committee of Kermanshah University of Medical Sciences (ethics approval number: IR.KUMS.REC.1397.656) and registered Iranian clinical trial registry (registration number: IRCT20201223049811N1), data of registration: 12.01.2021; https://en.irct.ir/trial/53230. Written informed consent was obtained from each studied subject after explaining the purpose of the study. The right of subjects to withdraw from the study at any time and subject's information is reserved and will not be published.

Consent for publication

Not applicable

Availability of data and materials

Data will be available upon request from the corresponding author.

Competing interests

All authors have no conflict of interest.

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No funding received for this study.

Authors' contributions

MS and MA contributed in conception and design of the research; MS, HK, and WT contributed to data collection; MA and WT contributed to the acquisition and analysis of the data; MA and WT contributed to the interpretation of the data; MS, MA, and WT contributed to draft the manuscript. All authors are in agreement with the manuscript and declare that the content has not been published elsewhere.

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Tables

Table 1: Basic characteristics of studied participants

Variables	Vitamin D+ water exercise	water exercise	Vitamin D without exercise	Control	P-value
	(n=10)	(n=10)	(n=10)	(n=10)	
Age, year	43.1±3*	41.5±2.7	43.8±3.65	42.8±4	0.33
Marital status, married %	90	90	80	80	0.43
Education, %					
Illiterate and under diploma	30	40	30	30	0.78
Diploma	50	40	40	40	0.78
Academic	20	20	30	30	0.78
Weight, kg	77.71±13.71	73.56±10.87	72.22±12.1	76.95±6.32	0.02
BMI, kg/m^2	29.65±65.13	30.15±3.8	29.58±6.46	30.3±3.53	0.09
WC, cm	91.5	93	92	93.5	0.11
BFM, kg	32.51±11.17	32.62±6.96	30.13±10.22	33.04±6.39	0.02
25 (OH) D3, ng/mL	37.1±4.37	32.3±6.5	36.2±8.3	31.3±3.3	0.33
Total MET, MET minute/ week	700±50	679±87	693±93	689±65	0.37
Sun exposure (minute/day)	84±21	91±18	85±31	90±27	0.13
SBP, mmHg	13.5±4.3	13.1±3.7	12.9±6.2	13.3±5.8	0.21
DBP, mmHg	8.2±3.8	7.5±2.2	7.4±3.1	7.9±1.9	0.31
Use of OCP	40	50	40	40	011

*Mean ± SD

P was obtained ANOVA and Chi- square.

Table 2. Energy and nutrients intake of patients with diabetes

Variables	Before (n=40)	After (n=40)	P1	P2	P3
Energy (kcal/day)					
Vitamin D+ water exercise	2715.4±221.4	2724.5±195.8	0.32	0.09	0.21
water exercise	2794.2±184.9	2787.1±210.4	0.24		
Vitamin D without exercise	2717.3±207.3	2745.4±186.2	0.11		
Control	2679.6±231.1	2690.5±204.3	0.33		
Protein (g/day)					
Vitamin D+ water exercise	128.3±22.4	130.8±18.6	0.23	0.1	0.17
water exercise	132.6±15.9	131.2±19.2	0.11		
Vitamin D without exercise	124.3±27.8	128.5±20.5	0.54		
Control	127.1±17.1	126.9±21.9	0.44		
Carbohydrate (g/day)					
Vitamin D+ water exercise	385.4±53.3	387.2±41.4	0.39	0.38	0.16
water exercise	398.1±39.8	396.6±46.2	0.43		
Vitamin D without exercise	388.3±49.5	391.8±50.8	0.33		
Control	381.7±44.2	383.5±29.7	0.44		
Fat (g/day)					
Vitamin D+ water exercise	73.4±20.3	72.5±18.3	0.28	0.21	0.33
water exercise	74.6±19.5	75.1±16.6	0.41		
Vitamin D without exercise	74.1±23.7	73.8±21.8	0.18		
Control	71.6±22.9	72.1±17.9	0.42		

*All presented values are means

P1: P values denote significance of within-group changes.

*Significant difference within group throughout the study ($P < 0.05$, paired samples t-test).

P2: P values denote significance of between-group difference in the baseline.

P3: P values denote significance of between-group difference after intervention.

* Significant difference between groups throughout the study (P < 0.05, ANOVA).

Table 3: Anthropometric indices among studied participant before and after intervention

Variables	Before (n=40)	After (n=40)	P1	P2
Weight, kg				
Vitamin D+ water exercise	77.71±13.71*	76.17±14.04	0.001	0.013
water exercise	73.56±10.87	72.96±10.65	0.031	
Vitamin D without exercise	72.22±12.1	71.27±11.77	0.208	
Control	76.65±10.98	76.8±5.84	0.51	
BMI, kg/m^2				
Vitamin D+ water exercise	29.65±65.13	28.56±5.25	0.001	0.006
water exercise	30.15±3.8	29.57±5.8	0.004	
Vitamin D without exercise	29.58±6.46	28.21±4.51	0.016	
Control	30.3±3.53	30.22±2.39	0.411	
WC, cm				
Vitamin D+ water exercise	91.5±5.1	90±±5.8	0.032	0.043
water exercise	93±5.4	92±4.9	0.08	
Vitamin D without exercise	92±4.3	91.9±3.6	0.34	
Control	93.5±3.4	93.4±3.1	0.42	
Body fat, kg				
Vitamin D+ water exercise	32.51±11.17	31.68±11.17	0.013	0.032
water exercise	32.62±6.96	31.78±6.81	0.001	
Vitamin D without exercise	30.13±10.22	29.65±9.67	0.042	
Control	33.04±6.39	32.51±5.41	0.31	

*All presented values are means ± SD.

P1; P values denote significance of within-group changes.

P2: P values denote significance of between-group difference after intervention.

*Significant difference within group throughout the study (P < 0.05, paired samples t-test).

* Significant difference between groups throughout the study (P < 0.05, ANOVA).

Table 4: Cardiometabolic profile among studied participant before and after intervention

Variables	Before intervention (n=40)	After intervention (n=40)	P1	P2
FBS, mg/dl				
Vitamin D+ water exercise	151.7±70.33*	132.4±17.22	0.042	0.041
water exercise	138.55±63.54	130.66±17.57	0.69	
Vitamin D without exercise	117.22±76.27	123.77±42.22	0.503	
Control	114.28±54.14	110±11.34	0.499	
HbA_{1C}, %				
Vitamin D+ water exercise	8.35±1.76	6.32±1.45	0.001	0.001
water exercise	8.57±1.5	7.95±1.34	0.039	
Vitamin D without exercise	7.74±1.49	6.76±1.21	0.004	
Control	7.39±1.18	7.3±1.11	0.263	
Insulin, pmol/L				
Vitamin D+ water exercise	12.78±5.98	9.34±3.65	0.001	0.031
water exercise	11.45±4.78	9.21±4.12	0.001	
Vitamin D without exercise	11.33±6.81	11.07±5.76	0.573	
Control	9.96±4.75	10.24±5.31	0.167	
HOMA-IR				
Vitamin D+ water exercise	2.89±1.13	1.68±1.02	0.001	0.001
water exercise	3.01±1.21	2.11±0.84	0.024	
Vitamin D without exercise	2.93±0.86	2.09±0.77	0.47	
Control	3.34±0.69	2.98±0.92	0.196	
TG, mmol/L				
Vitamin D+ water exercise	183.56±33.46	149.67±29.28	0.001	0.032
water exercise	197.08±24.87	168.54±32.91	0.039	
Vitamin D without exercise	189.7±46.23	178.43±39.54	0.156	
Control	201.49±58.32	190.22±46.19	0.342	
Total cholesterol, mg/dL				

Vitamin D+ water exercise	160.43±20.81	142.66±29.47	0.001	0.025
water exercise	171.24±32.14	155.43±26.31	0.014	
Vitamin D without exercise	158.16±29.41	149.4±19.06	0.121	
Control	142.09±35.97	150.31±31.84	0.139	
HDL, mmol/L				
Vitamin D+ water exercise	40.68±11.31	42.54±13.93	0.037	0.037
water exercise	39.55±8.45	41.01±13.45	0.027	
Vitamin D without exercise	40.66±11.91	39.55±10.01	0.267	
Control	47.57±14.88	47.85±13.37	0.794	
LDL, mg/dL				
Vitamin D+ water exercise	82.47±19.98	85.65±30.11	0.003	0.024
water exercise	91.68±29.67	69.44±21.83	0.005	
Vitamin D without exercise	80.12±25.44	70.94±35.23	0.573	
Control	89.34±27.41	90.67±28.59	0.167	
CRP, mg/dL				
Vitamin D+ water exercise	4.01±1.69	2.98±1.26	0.003	0.013
water exercise	3.98±2.09	3.75±1.76	0.541	
Vitamin D without exercise	3.54±0.54	3.26±0.52	0.486	
Control	3.63±1.32	3.89±0.79	0.629	

*All presented values are means ± SD.

P1; P values denote significance of within-group changes.

P2: P values denote significance of between-group difference after intervention.

*Significant difference within group throughout the study ($P < 0.05$, paired samples t-test).

* Significant difference between groups throughout the study ($P < 0.05$, ANOVA)

Figures

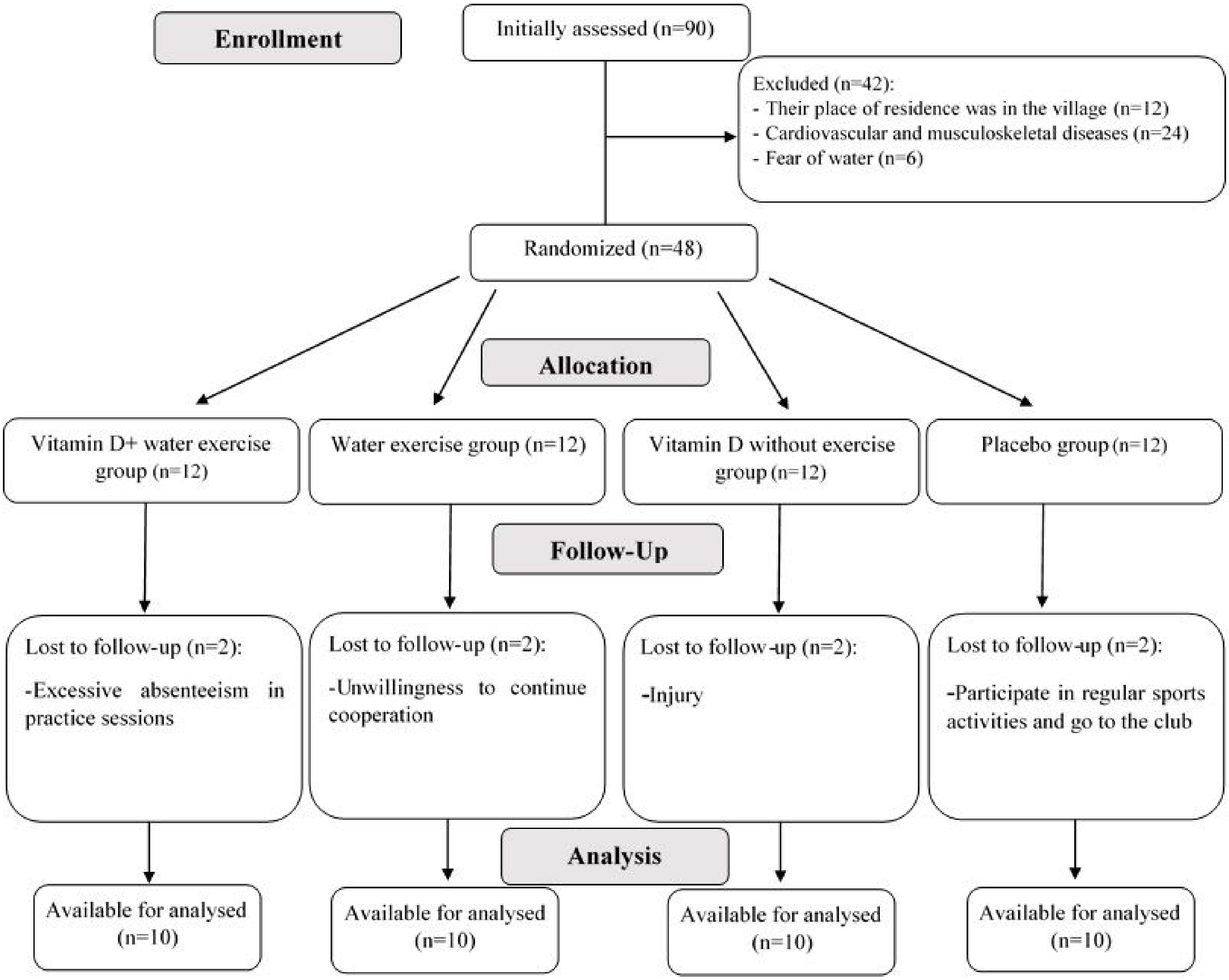

Figure 1

CONSORT flow chart of study.