Effect of Postpartum Aerobic Exercises on Vitamin D and Ionized Calcium Levels: A randomized controlled trial

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ABSTRACT

Background: Vitamin D and calcium levels are negatively affected during postpartum period, making postnatal woman more vulnerable to health issues and consequently lowering her quality of life**.**

Objective: This study examined the effect of aerobic exercise of moderate intensity on postpartum women's vitamin D and ionized calcium levels.

Patients and Methods: A randomized controlled clinical trial was conducted on 40 postnatal women. Participants' ages ranged from 20 to 35 years old. The investigation was carried out at Al-Zahraa University Hospitals in Cairo in the Gynecology Department's Outpatient Clinic. Participants were randomly assigned into two equal groups: Control group (*Group A*) who did not perform any type of exercise during the study duration (n = 20), and intervention group (*Group B*) who were engaged in aerobic exercise program consisting of treadmill walking for 40 minutes, three times per week, for 12 weeks (n = 20). All postnatal women in both groups were evaluated by measuring serum vitamin D and ionized calcium levels before and after the treatment program.

Results: Post-treatment comparison showed that *Group B* had a considerable advantage over *Group A* in terms of the mean values of vitamin D and ionized Ca++ levels (P=0.015*, P=0.003* respectively).

Conclusion: Aerobic exercise is effective in increasing levels of serum vitamin D and ionized calcium in postnatal women.

Keywords: Aerobic exercises, Vitamin D status, Ionized calcium, Postnatal.

INTRODUCTION

Postpartum period is a crucial phase in woman's life cycle since she is more susceptible to health problems at this time [1, 2] that can have long-term consequences for her and her family [3,4].

Such as early breastfeeding termination, negative mother perceptions of a baby, delayed language development, poor maternal-child connection, lower childhood vaccination rates, and growing rates of behavioral problems in children [5].

During the postpartum period, calcium and vitamin D levels are negatively affected [1,6,7]. A previous study observed that 49% of German pregnant women have insufficient vitamin D status in the summer, and this percentage rises to 98% after the birth of a child in the winter [8]. Besides that, lactation is considered a crucial period of accelerated bone turnover that can raise the risk of osteoporosis and hypocalcemia [9,10].

Vitamin D deficiency has been related to postpartum depression [11]. It is also linked with increased autoimmunity, vulnerability to infection**,** and susceptibility to cardiovascular disease [12,13].

Maintaining normal vitamin D and calcium levels is essential since vitamin D regulates calcium absorption, preserves calcium and phosphorus homeostasis, and supports a diversity of physiological and metabolic functions [14,15]. Additionally, it reduces inflammation, modulates processes such as cell growth, neuromuscular function, and glucose metabolism in the body**,** and protects against musculoskeletal health problems, and cancer [16,17] while calcium is an essential mineral for vascular contraction and vasodilation, blood pressure regulation, bone development, muscle function, nerve transmission, intracellular signaling, and hormonal secretion [18].

Maintaining normal calcium and vitamin D level can be attained through supplementation [19,20]. However, overdose can cause hypercalcemia, which can lead to anorexia, nausea, vomiting, and diarrhea, as well as polyuria and polydipsia, weakness, weight loss, sleeplessness, irritability, anxiety, severe depression, itching, proteinuria, and potentially renal failure [21].

As a result, finding safe treatment options with no side effects is critical. Up to our knowledge, there is no research exploring the impacts of aerobic exercise on vitamin D in postnatal women. Previous research, however, concentrated on the exercise impacts upon vitamin D in women during pregnancy [22] and post menopause [23], neglecting the postpartum period, which is considered a crucial period for women. Therefore, our study was set out in order to study the impact of aerobic exercise on vitamin D and ionized calcium in postnatal women.

PATIENTS AND METHODS

Study design

The study's design was a randomized controlled clinical trial. The participants were randomly allocated into two groups that were matched and equal in number. The control group (N= 20) did not exercise at all during the study, whereas the intervention group (N= 20) engaged in aerobic exercise consisting of treadmill walking for 40 minutes, three times per week for 12 weeks. The investigation was carried out at Al-Zahraa University Hospitals in Cairo in the Gynecology Department's

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Outpatient Clinic. The study was conducted from April 2021 to April 2022.

Randomization

A total of 45 postnatal women were enrolled to participate in the study, as shown in **Figure 1**. Three of them didn't match the criteria for inclusion and the other two declined to sign the informed consent form. After the participating women had been fully briefed of the procedures of study, they have signed a form of consent in which they agreed to take participation in the study, in accordance with the declaration of Helsinki. Participating women were assigned into two even groups in random manner (the control and intervention groups) using a sealed envelope method. Randomization was done by an independent researcher, and after randomization, no participants dropped out of the study.

Participants

A total of 40 sedentary postnatal women participated in this study. The inclusion criteria were as follows: (1) Their ages varied from 20 to 35 years; (2) They were between the 6^{th} and 8^{th} weeks postpartum; (3) All of the women were in good health and had no serious illnesses; and (4) They were suffering from vitamin D deficiency or insufficiency; (5) They were breastfeeding.

Women were excluded if they had epileptic fits or cardiac affection; renal, liver, or endocrine disorders; were at risk for pulmonary or lung disease; or were using a pacemaker. Postnatal women who were involved in any type of exercise program, who used drugs or supplements, who had a preexisting condition that prevented them from engaging in an exercise intervention, who were taken fortified food, and/or who smoked were also excluded from the study.

Demographic information was taken from each postnatal woman such as her age, weight, and height. Also, they were questioned about if they were taken any supplements or fortified food.

Sample size

Sample size calculations were made utilizing G*Power statistical software (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany). The calculation indicated that the needed size of sample for this research was 13 patients per group based on information on blood vitamin D provided from **Aly *et al.*** [23], who found a significant variation in serum vitamin D among exercise and no exercise groups. The following values were used in the calculations: $\alpha = 0.05$, power = 95%, magnitude of effect = 2.9 and ratio of allocation N2/N1 = 1.

In the exercise group, the mean (SD) blood vitamin D level (nmol/L) was 6.12 (SD 1.38), whereas it was 3.27 (SD 0.11) in the non-exercise group. For each group, the sample size was raised to 20 individuals in order to account for missing data and boost the study's power.

Outcome measures:

Vitamin D serum level: Each individual was instructed to adopt a half-lying position, with her back and arms well supported. Alcohol was used to clean the antecubital area. A blood sample was collected from each woman's antecubital vein using a single-use sterile syringe. The most reliable indication of status of vitamin D is serum 25-hydroxyvitamin D (25(OH)D), as it reflects both vitamin D intake and endogenous vitamin D synthesis [24, 25]**.** High-performance liquid chromatography (Shimadzu, Japan) was used to assess 25(OH)D serum levels before and after the study program in both groups, using 25-OH vitamin D ELISA. Kits (Life Sciences Inc. USA). Values of 25(OH)D < 20 ng/ml are considered deficient, values ranged 21 to 29 ng/ml are considered insufficient, and 30 ng/ml is considered ideal [26].

Ionized calcium serum level: Each woman was asked to rest for at least 15 minutes before venipuncture to avoid the effect of activity on her calcium level, using evacuated serum collection tubes. All participants in both groups had their serum ionized calcium levels measured before and after the intervention, using EasyLyte Ca analyzer (USA) which utilizes ISE (Ion Selective Electrode) technology in order to measure electrolyte. The manufacturer's instructions were followed at all times. In adults (18–60 years), the reference value of serum calcium is 1.05–1.3 mmol/L [27]**.**

***Intervention*:**

Aerobic exercise program:

Each postpartum woman in the study group performed aerobic exercise three times a week, for a total of twelve weeks. Each session of exercise was divided into three phases: warm-up, active exercise, and cool-down. The phase of warm-up consisted of 5 minutes of low-speed walking on a treadmill (Biodex Gait Trainer 2, USA) to prevent musculoskeletal injuries. The active phase lasted 40 minutes and was performed at a moderate intensity of 40 to 60% of maximum heart rate (HRmax). Each woman's prescribed intensity was increased gradually, and her speed was adjusted in accordance with her HRmax which was resulted by deducting the age from 220 [28]**.** During the 5-minute cool-down phase, treadmill speeds were dropped gradually till resting heart rates were reached. All exercise sessions were done under supervision.

Ethical approval:

Ethics Committee of the Faculty of Physical Therapy, Cairo University, Egypt approved the study with ID number (P.T. REC/012/003188). Written informed consent was obtained from all participants. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis:

The Statistical Package for Social Sciences (SPSS) software was used in order to analyze the data for Windows (Standard version 26). The Shapiro test was applied to examine the data's normality. Since data were normally distributed, we represented continuous variables using the mean and standard deviation (SD). Qualitative data was expressed as absolute frequencies (number) and relative frequencies (percentage). The paired t test was applied to compare paired groups, whereas the student t test was utilized to compare quantitative data between the two independent groups (parametric). To evaluate quantitative data between the two independent groups, the test of Mann-Whitney was utilized (non-parametric). Chi square test ($\chi 2$) to calculate difference between two or more groups of qualitative variables. The level of significance for all of the aforementioned statistical tests is set at 5%. The findings were deemed significant when $p \leq 0.05$. The findings are more significant the lower the p-value that was attained.

RESULTS

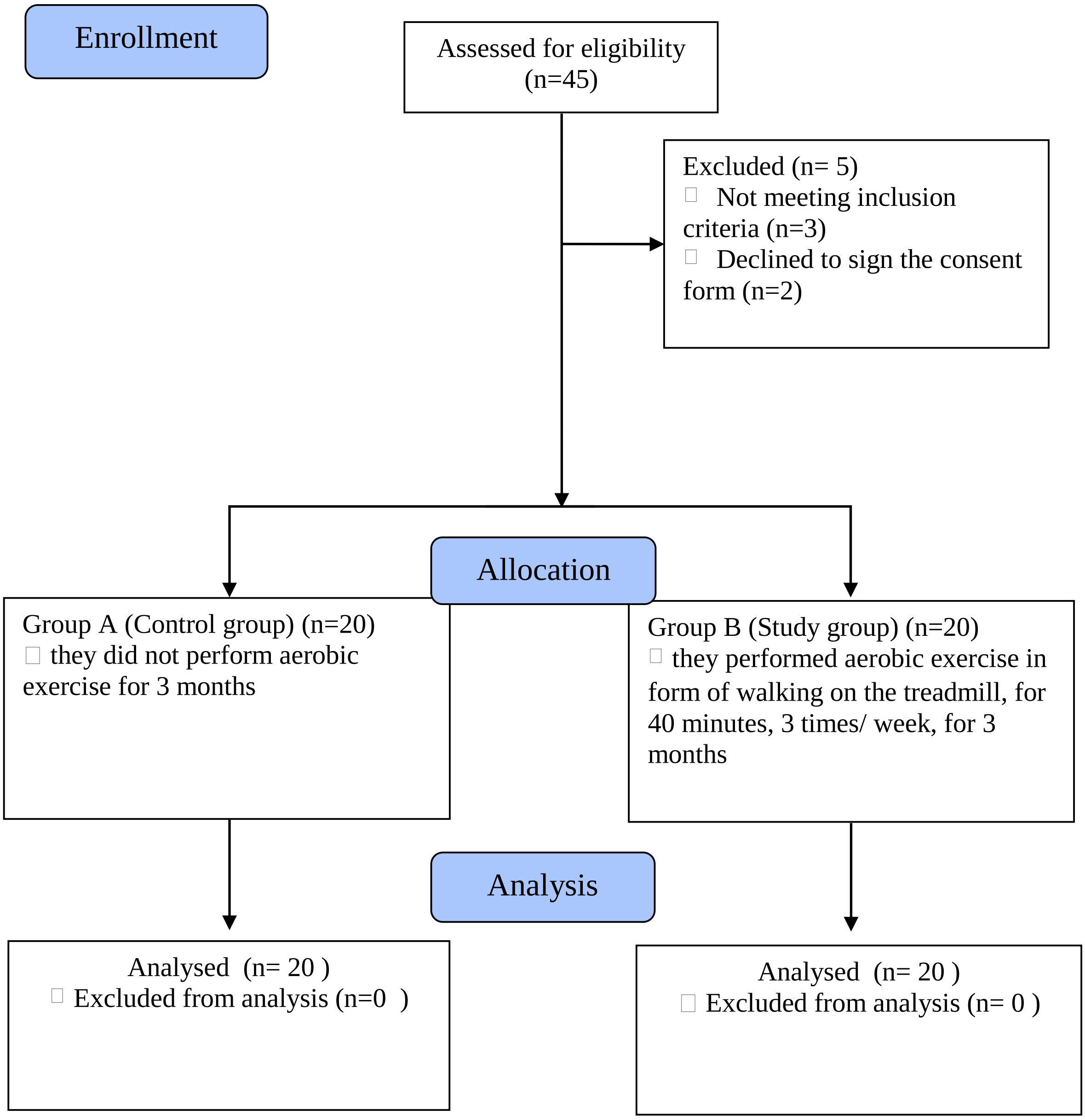

Figure 1: Flow chart of the study.

I- General features of postnatal women in both groups:

Group A (Control group): This group consisted of 20 postnatal women. Their age, weight, height, and BMI are summarized in *Table 1*.

Group B (Intervention group): This group consisted of 20 postnatal women. Their age, weight, height, and BMI are summarized in *Table 1*.

When comparing the individuals in both groups, there's no statistical difference (P >0.05) in the mean age, weight, height, or BMI between the groups.

Table (1): General features of postnatal women in both groups (A&B).

Variable	Control group	Study group	T test	P value
Age	29 ± 4.55	28.25 ± 4.39	0.530	0.599^{NS}
Height	163.2 ± 4.08	163.5 ± 4.65	0.217	0.830^{NS}
Weight	82 ± 7.94	86.2 ± 6.51	1.83	0.075^{NS}
BMI	30.78 ± 2.52	32.07 ± 1.67	1.90	0.065^{NS}

Expression of data was carried out as mean ± SD; NS: non-significant; BMI: body mass index.

II. Vitamin D:

As presented in table (2), the mean value of Vitamin D for control group was 21.60 pre-study. Whereas, after study program it became 21.90, with a percentage of increase =1.4%. That increase in Vitamin D was figured out to be no statistically significant (P= 0.333). The mean value of Vitamin D for intervention group was 21.37 pre-study. Whereas, after study program it became 26.05, with a percentage of increase =21.8%. That increase in Vitamin D was revealed to be highly statistically significant (P= 0.001*). On comparing both groups (A&B) as regarding Vitamin D, there was no statistically significant difference pre-study (P = 0.911), however there was significant difference after study program (3 months) (P =0.015*) between both groups favoring study group.

Table (2): Mean values of Vitamin D level (ng/ml) for the pre-treatment and post-treatment in both groups (A&B).

Vitamin D level	Control group (N= 20)	Study group (N= 20)	T test	P value
Pre-study	21.60±5.19	21.37±5.31	t=0.112	0.911^{NS}
Post-study	21.90±5.41	26.05±3.98	t=2.54	0.015*
Change %	1.4%	21.8%	---	
Paired t test Before Vs. after	t=0.993	t=4.94		
P value	$P=0.333^{NS}$	P=0.001*		

Expression of data was carried out as mean ± SD, *significant p ≤0.05; NS: non-significant

III. Ionized Ca++:

The mean SD value of ionized Ca++ for control group was 1.09 pre-study. After the control program it became 1.10 with a percentage increase of 0.53%. That increase in ionized Ca++ was revealed to be highly non-statistically significant (P = 0.1655). The mean value of ionized Ca++ for study group was 1.11 pre-study. After the intervention program, it became 1.24, with a percentage increase of 11.7%. That increase in ionized Ca++ was shown to be highly statistically significant (P = 0.006*). On comparing both groups (A and B), there was no statistically significant difference pre-study (P= 0.407), while there was a significant difference after the study program (3 months) (P= 0.003*) in favor of group B (**Table 3**).

Table (3): Mean values of Ionized Calcium level (mmol/L) for the pre-treatment and post-treatment in both groups (A&B):

Calcium level (mmol/L)	Control group (N= 20)	Study group (N= 20)	Test of significance	P value
Ca (before) Mean ± SD	1.09 ± 0.09	1.11 ± 0.09	t=0.839	0.407^{NS}
Ca (after) Mean ± SD	1.10 ± 0.093	1.24 ± 0.17	t=3.18	0.003*
Change %	0.53%	11.7%	---	
Paired t test Before Vs. after	t=1.45	t=3.09		
P value	$P=0.165^{NS}$	P=0.006*		

Expression of data was carried out as mean ± SD, *significant p ≤0.05; NS: non-significant

DISCUSSION

This study assessed the impacts of aerobic exercise on postpartum women's vitamin D status and ionized calcium. Our results revealed a considerable significance between both groups in the post-treatment mean levels of vitamin D and ionized calcium favoring group B.

To our knowledge, this is the first study to have investigated the impact of aerobic exercise on vitamin D in postnatal women. Previous research, however, has found that exercise has a positive effect on vitamin D levels. Such as **Gustafsson *et al.*** [(21)] who revealed that exercise programs may impact status of vitamin D in positive manner among healthy pregnant women. Moreover, **Malandish *et al.*** [(22)] found that moderate-intensity aerobic exercise for 12 weeks without added vitamin D supplementation raised concentration of serum vitamin D, with participants going from severe status of vitamin D deficiency (below 10 ng mL) to vitamin D deficient status (between 10 and 20 ng mL). In addition to that, **Aly *et al.*** [(24)] showed that diabetic rats had considerably enhanced status of vitamin D after engaging in swimming activity. They had higher levels of serum vitamin D correlated with greater vitamin D receptors in adipose, pancreas tissue, and muscle.

Previous research has shown a link between physical activity and increased levels of serum vitamin D; this may be due to increased vitamin D metabolism or greater exposure to sunlight [(25)]. The study by **Wanner *et al.*** [(29)] found that those whose exercise took place outdoors had considerably higher 25(OH)D levels than those whose exercise took place indoors. However, because the exercise sessions in our study were indoors, the increase in vitamin D level can be explained by **Dzik *et al.*** [(30)]**,** who stated that vitamin D receptors in skeletal muscles might perhaps regulate local control of vitamin D metabolism, so during the exercise, the muscular stores of vitamin D are activated and vitamin D is released into the circulation. In accordance with **Mason *et al.*** [(31)]**,** muscle serves as a significant site of 25-(OH)D sequestration, preventing the molecule from being degraded in the liver and returning it back into the circulating blood when it is needed. This may justify the correlation between exercising, not only outdoors, and higher vitamin D levels.

Regarding the aerobic exercise's impact on ionized calcium, our results are in line with **Fouad *et al.*** [(19)] who conducted that aerobic exercises are effective in increasing serum calcium level and treatment of hypocalcemia compared with calcium supplementation.

Additionally**, Alghadir *et al.*** [(32)] who assessed bone markers in healthy individuals (men and women) found that 12 weeks of moderate aerobic exercise, three sessions per week, resulted in a significant enhancement in all indices of bone metabolism, comprising serum free calcium, serum osteocalcin, and bone mineral density. As well, **Narattaphol** [(33)] noted that exercise improves bone health and calcium metabolism by boosting bone mineral density and lowering urine calcium loss.

Moreover, **Colleran *et al.*** [(34)] who reported that postnatal women who performed both aerobic and resistance interventions significantly lost less lumbar spine BMD within the initial 20 weeks postpartum leading to higher level of lumbar spine BMD at first year postpartum as brought in comparison to women who hadn't had exercised within the initial 16 weeks.

Likewise, **Al-Dahamsheh *et al.*** [(9)] looked into the effect of aerobic exercise, three times per week for 60 minutes, for 12 weeks on female bone health indicators, and found that aerobic exercise significantly improves serum calcium levels and restores calcium homeostasis, which is necessary for various biological processes, including bone metabolism, improving bone health, and reestablishing bone tissue's hemostasis. They suggested that aerobic exercise stimulates parathyroid glands to generate and release more parathyroid hormone (PTH), which then causes calcium to be released from its reserves and enter the circulation. Besides that, **Charoenphandhu** [(35)] reported that aerobic exercise enhanced intestinal calcium absorption in vivo, albeit the exact mechanisms are still being debated.

Strengths of the study:

Multiple strengths are found in this study, including that it is among the first studies to research the effect of aerobic exercise on vitamin D status and ionized calcium during the postnatal period. Also, the calculated sample size, randomized design, objective evaluative criteria, and treatment procedures provided by an experienced physiotherapist are additional strengths of this study.

Limitations of the study:

This study has some limitations as it lacks a follow-up period, which is necessary to ascertain the long-term impact of aerobic exercise. As well, no information on socio-economic data is included. Future research is required to address these issues.

CONCLUSION

Aerobic exercise increases vitamin D and ionized calcium levels in postnatal women, improving their health and quality of life.

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