Supplementation of vitamin D reduces energy intake and prevents body fatness accumulation in obese woman

Linda Sinto¹*, I Wayan Weta², Komang Bagus Satriasa³, Nyoman Mantik Astawa⁴

ABSTRACT

Introduction: Obese people are at higher risk of comorbidities, including metabolic syndrome, autoimmune, tumor progression and other inflammation diseases because of low-grade chronic inflammation. Vitamin D is closely related to transcriptional activity in adipose tissue, which regulates adipogenesis, inflammatory pathways, and adipocyte cell metabolism. This research aims to know the effect of Vitamin D supplementation on energy intake and body fat accumulation.

Methods: 40 obese women between the ages of 26 and 45 were randomly assigned to the Intervention and Control groups, which received daily supplements of 5000 IU of vitamin D and a placebo, respectively. Data were gathered before the intervention and after 12 weeks of it. We measured the energy intake, BMI, waist circumference (WC), and conicity index. The participants were told to keep their daily calorie consumption at or below 1500 kcal.

Results: After 12 weeks of supplementation, 25(OH) Vitamin D levels increased significantly (p=0.001), and energy intake decreased (p=0.014) significantly in the intervention group, but no change in the control group (p>0.05). Body fatness indices (BMI and WC) increased (p=0.005 and p=0.003) significantly in the control group; however, these parameters did not change in the intervention group (p>0.05).

Conclusion: Daily Vitamin D 5000 IU for 12 weeks decreases energy intake and prevents body fat accumulation in obese women.

Keywords: Vitamin D, Obesity, Body Fat.

INTRODUCTION

Obesity is one of the major health challenges in this century. In obesity, there is hyperplasia and hypertrophy of fat cells, which result in changes in the metabolic activity of adipose cells.¹ Previously, adipose tissue was only considered a fat storage organ, but this view has changed. Adipose tissue is an active endocrine tissue that produces various adipokines and plays a role in metabolic regulation.² Adipose tissue is an essential organ for maintaining energy homeostasis and glucose metabolism and an endocrine organ for releasing fatty acids and synthesizing proteins.³ Adipose tissue is dominated by adipocytes surrounded by a matrix of collagen fibers, fibroblasts, blood vessels and immune cells. Fat deposits, adipocyte hypertrophy and collagen fibrosis in the extracellular matrix lead to hypoxia, stress on the endoplasmic reticulum and oxidative stress, resulting in the retention of pro-inflammatory cytokines such as IL-6 and TNF-α.

Vitamin D is closely related to the transcriptional activity in adipose tissue, which regulates adipogenesis, inflammatory pathways, and adipocyte cell metabolism. In the current study, we aimed to investigate the effect of vitamin D supplementation on energy intake and body fat accumulation in obese women.

METHODS

The design of this study is a double-blind, randomized controlled trial conducted from October 2022 to April 2023. The study sample is obese women 26-45 years old who lived in East Jakarta and were chosen by consecutive sampling. The amount of sample was calculated with the formula described by Pocock, resulting
in the amount of sample in each group being 17 people. To anticipate incomplete data, the sample was added 10% so that the number of samples was rounded to 20 people in each group.

A total of 40 women met the following entry criteria: BMI ≥25kg/m² and waist circumference ≥80cm, Vitamin D level deficiency (≤30 ng/mL) and showed their interest in participating in the study. Women on Vitamin D supplementation, hypertension drugs, anti-cholesterol drugs, antidiabetic drugs in the last 3 months, hormonal therapy, pregnant, menopause, liver and kidney disease were excluded from the study.

These 40 women were equally divided into the control group (n = 20) and the intervention group (n = 20), as shown in Figure 1. Before starting the study, informed consent was obtained, and participants' anonymity was upheld at all times. The Universitas Udayana/Sanglah Hospital Research Ethics Committee approved the study protocol. The control group received a daily placebo containing amyllum, while the intervention group received 5000 IU of vitamin D daily. Additionally, intervention and control group participants were advised to limit their daily calorie consumption to no more than 1500 kcal. We held weekly meetings every Friday to keep the participants compliant. A week's worth of supplements were given to the attendees at this conference.

Complaints and any side effects that the supplements might have brought were tracked and recorded. The amount of supplements still in a used bottle container was counted weekly to ensure it was eaten as directed. If adherence to ingesting vitamin D falls below 80% of the total days of vitamin D administration throughout the trial, research subjects will be removed.

**Data collection**

**Assessment of Food Intake**

Semi-quantitative FFQ (SQ-FFQ) techniques were used to assess dietary consumption twice, at the baseline and end-line. SQ-FFQ data conversion from food to daily nutritional intakes.

**Anthropometric and Biochemical Assessment**

At the beginning and end, anthropometric and biochemical characteristics were measured twice. A digital scale with a resolution of 0.1 kg, the Karada Scan, was used to measure body weight (BW). A microtoise was used to measure body height (BH) with an accuracy of 0.1 cm. Waist circumference (WC) was measured using a flexible non-elastic tape, exactly at the middle level of the abdomen, with a precision of 0.1 cm. Vitamin D level measured in serum taken from peripheral blood samples by ELISA method using a spectrophotometer machine with BT Lab Cat. No E3860Hu Reagent. Body Mass Index (BMI) was calculated by BW (kilogram) divided by BH (meter) squared. The Conicity Index was calculated using the following mathematical equation: waist circumference/0.109 × √weight/height.

**Statistical Analyses**

SPSS Statistics 20 was used to conduct the statistical analysis. The standard error of the mean (SE) displays data with a normal distribution, whereas the median (interquartile) displays data with an aberrant distribution. Using the paired t-test for data with a normal distribution and the Wilcoxon test for data with an abnormal distribution, comparisons and changes within groups were compared. An independent t-test was used to evaluate group differences for data with a normal distribution, and for data with an abnormal distribution, a Mann-Whitney test was used. The cutoff for statistical
Table 2. Comparison of 25(OH) Vitamin D levels (ng/ml), daily energy intake (kcal), BMI and waist circumference (cm) pre-test and post-test based on treatment group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>p*</th>
<th>p***</th>
</tr>
</thead>
<tbody>
<tr>
<td>25(OH) Vitamin D (ng/ml)</td>
<td>Control</td>
<td>Intervention</td>
<td></td>
</tr>
<tr>
<td>Pre-test</td>
<td>9.68 (9.67)</td>
<td>7.24 (5.11)</td>
<td>0.277</td>
</tr>
<tr>
<td>Post-test</td>
<td>7.95 (3.92)</td>
<td>13.12 (11.54)</td>
<td>0.001</td>
</tr>
<tr>
<td>Delta</td>
<td>-3.08 (7.31)</td>
<td>7.14 (6.78)</td>
<td>0.001</td>
</tr>
<tr>
<td>p**</td>
<td>0.156</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Daily energy intake</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test</td>
<td>1917±366</td>
<td>1731±372</td>
<td>0.120</td>
</tr>
<tr>
<td>Post-test</td>
<td>1917±415</td>
<td>1541±242</td>
<td>0.001</td>
</tr>
<tr>
<td>p****</td>
<td>0.989</td>
<td>0.014</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test</td>
<td>27.6 (4.60)</td>
<td>26.4 (3.93)</td>
<td>0.174</td>
</tr>
<tr>
<td>Post-test</td>
<td>28.5 (5.28)</td>
<td>26.1 (3.54)</td>
<td>0.056</td>
</tr>
<tr>
<td>p**</td>
<td>0.005</td>
<td>0.985</td>
<td></td>
</tr>
<tr>
<td>Waist Circumference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test</td>
<td>92 (14)</td>
<td>88 (13)</td>
<td>0.102</td>
</tr>
<tr>
<td>Post-test</td>
<td>93.5 (16)</td>
<td>87 (12)</td>
<td>0.060</td>
</tr>
<tr>
<td>p**</td>
<td>0.003</td>
<td>0.818</td>
<td></td>
</tr>
</tbody>
</table>

*Mann-Whitney ** Wilcoxon *** independent t-test **** paired t-test

Significance was p<0.05.

RESULTS

All intervention and control group participants were comparable in baseline age, energy intake, and anthropometric and body fat index values. All baseline characteristic of placebo and supplemented groups is shown in Table 1. The mean age in the control group is 39.2±9.32, and the mean age in the treatment group is 40.8 ± 6.65. This age is when the woman is productive in both hormonal and activity, so by choosing the sample with those age ranges, the subject is expected to be active hormonally. All of the subjects have type IV skin color according to Fitzpatrick's skin color classification. The skin quality at an older age and darker skin color (high melanin) can also slow down the production process of vitamin D. The baseline average body mass index in the control group is 27.6(4.60) vs. 26.4(3.93) kg/m2 in the intervention group. It shows the value is categorized as obese based on criteria from Asia Pacific (BMI>25kg/m2) and WHO (BMI>30kg/m2).

In obese patients, there is a decrease in the bioavailability of vitamin D and a lot of vitamin D 25(OH)D is trapped in adipose tissue. Increased oxidation reactions in adipose tissue can also cause damage from vitamin D. The sequestration theory, supported by Lin et al. research, says that obese individuals have high adipose cells, thereby depleting their vitamin D reserves. Volumetric dilution theory is another probable mechanism. Even though obese and lean subjects have similar amounts of Vitamin D, in overweight people, Vitamin D is distributed dominantly into serum, muscle, fat and liver – compartments that are increased in obesity, making serum concentrations lower. This theory suggests that weight loss will increase Vitamin D serum levels. Nevertheless, the weight loss study shows inconsistent results. This causes a decrease in 25(OH)D levels in the blood. Another cause may be the lack of outdoor activities since most subjects work in offices and are housewives. This study found that all subjects experienced a deficiency of 25(OH) Vitamin D (Table 2). Muscogiuri also found a significant correlation between deficiency in serum levels of 25(OH)D and obesity.

DISCUSSION

After supplementation, there was a significant increase in Vitamin D levels in the intervention group (7.24(5.11) to 13.12(11.54); p=0.001), whereas in the control group, there was a decrease in Vitamin D levels (9.68 (9.67) to 7.95 (3.92); p=0.156). Vitamin D levels in the pre-test between groups were not significantly different (p=0.277), while the post-test in the intervention group was found to be higher than the control (p=0.001) (Table 2). Previous research, giving Vitamin D 5000 IU per day for 12 weeks to obese people increased 25(OH)D levels by an average of 15.6 ng/mL and 5.6 ng/mL in obese people who were given Vitamin D 1000 IU/day for 12 weeks. Based on previous trials during medical weight loss programs, to increase 25(OH)D levels to ≥30ng/mL, the dose of Vitamin D needed was 1200-4600IU/day for 12 months.

Low Vitamin D levels in obese people could also be affected by high leptin levels. Leptin stimulates osteocytic fibroblast growth factor 23 (FGF23) in this mechanism. FGF-23 inhibits 1α-hydroxylase synthesis in the kidney and consequently interferes with 1,25(OH)2D3 production. An in vitro study by Menendez et al. found that leptin secretion from adipose tissue was negatively correlated with 25(OH)D levels. High levels of Vitamin D can suppress the formation of leptin in obesity. This can ameliorate the disastrous consequences of obesity. Meanwhile, increased leptin production in obese patients will reduce the conversion of 25(OH)Vit D to 1,25(OH)2D3.

Increased levels of Vitamin D in the treatment group may impact leptin production. Leptin will signal the nervous system to reduce food intake and increase energy use. In this study, it can be shown by the trend of a significant decrease in daily intake in the intervention group (1731±372 to 1541±242; p=0.014), whereas in the control group, there was an increase in energy intake (1917±366 to 1917±415; p=0.989). Energy intake in the post-test between groups was not significantly different (p=0.120), while the post-test in the intervention group was found to be lower than the control (p=0.001) (Table 2). There is a plausibility that Vitamin D also affects the central control of appetite in the hypothalamus.

Changes in Vitamin D levels and daily intake will affect changes in body BMI.
There was a significant increase in BMI in the control group (27.6(4.60) to 28.5(5.28); p=0.005), whereas in the intervention group, there was no significant increase of BMI (26.4(3.93) to 26.1(3.54); p=0.985). BMI between groups was not significantly different in the pre-test (p=0.174) and also in the post-test (p=0.056) (Table 2). For waist circumference, there was a significant increase in the control group (92(14) to 93.5(16); p=0.003), whereas in the intervention group, there was a decrease in waist circumference (88(13) to 87(12); p=0.818). Waist circumference between groups was not significantly different in the pre-test (p=0.102) and also in the post-test (p=0.060) (Table 2).

A study involving 383 obese women stated an increase in 25(OH)D levels by an average of 2.7 ng/mL in the group with a weight loss of 5-10% from the initial body weight. There was an average increase in 25(OH)D levels by 5.0 ng/mL in the group with a weight gain of >10% of initial body weight.8 In this study, a decrease in BMI in the treatment group did not occur, and there was no significant change in the Conicity Index change in the control group (p=0.520) and in the intervention group (p=0.733). Waist circumference between groups was not significantly different in the pre-test (p=0.296) and the post-test (p=0.285), possibly due to increased Vitamin D levels in the treatment group, which had not exceeded sufficient Vitamin D levels. A previous randomized trial for a weight loss program with 2000 IU/d of Vitamin D vs. placebo for 12 months found that although changes in BMI and waist circumference were not significant, in those women whose 25(OH) Vitamin D level ≥ 32ng/ml lost significantly more weight and reduce their waist circumference than women who 25(OH) Vitamin D level achieve <32 ng/mL.6 The limitation of this research is the difficulty of interfering with the diet and physical activity of the research subjects since this research was done in humans. This study did not examine hormone levels that can influence obesity.

CONCLUSION

Daily supplementation of Vitamin D 5000 IU for 12 weeks decreased the energy intake and prevented body fatness accumulation in obese women in Jakarta.

ETHICAL CLEARANCE

This study has obtained ethics approval from the Research Ethics Committee Faculty of Medicine Universitas Udayana No. 2568/UN14.2.2.VII.14/IT/2022 before the study was conducted.

CONFLICT OF INTEREST

We declare that there were no conflicts of interest in this study.

FUNDING

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AUTHOR CONTRIBUTION

All of the authors equally contributed to the study.

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