# The Effect of a High-intensity Interval Training on Plasma Vitamin D Level in Obese Male Adolescents

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## Abstract

**Background:** The worldwide increasing vitamin D deficiency in adolescents is alarming. The effect of high-intensity trainings on adolescent health is not clear. **Object:** This study aimed to examine the effect of a high-intensity interval training (HIIT) on plasma level of vitamin D in overweight male adolescents. **Materials and Methods:** About 96 overweight students aged 12–16 years from two high schools participated in the study. The schools were randomly assigned to the intervention group ($n = 52$) and the control group ($n = 44$). For the intervention group, HIIT was performed 3 days per week for 8 weeks, while the control group was asked to walk outdoors at the same time. **Results:** At the end of the study, the vitamin D level was increased to 1.21 ng/dl in the intervention group, whereas it decreased to 1.94 ng/dl in the control group ($P = 0.003$). **Conclusion:** About 8 weeks of HIIT improved plasma level of vitamin D in overweight male adolescents. More prolonged interventions consisted of both the sex and broader age ranges are warranted.

**Keywords:** High-intensity interval training, male adolescent, vitamin D

## Introduction

Vitamin D deficiency is a major health problem. Vitamin D is especially important during the childhood because of its role in skeletal growth.[1] Recent studies have also emphasized on the effects of vitamin D in the prevention of heart diseases, malignancies, and infectious diseases. About one million people in the world have severe vitamin D deficiency[1] and about 37% of European and 72.4% of Iranian children suffer from vitamin D deficiency.[2]

The effective factors on the level of vitamin D include age, food intake, vitamin D supplements, sun exposure, and physical activity.[3] The amount of vitamin D that is supplied from diet is mostly not sufficient for the body requirements. Moreover, fortified foods are not sufficiently available in developing countries to meet the needs of children and young people.[4] Exposure to sunlight, which is required for ultraviolet-B (UVB)-induced vitamin D production in the skin, is the most important source of vitamin D in many developing countries.[5] Many studies have shown that physical activity may influence the synthesis, absorption, or metabolism of vitamin D.[6] The physical activity may increase 1,25-dihydroxyvitamin D3 (calcitriol) levels through an increased plasma insulin-like growth factor-1 (IGF-1).[7] Interestingly, recent studies reported that different types of physical activities can differently affect the plasma level of vitamin D. For example, Van den Heuvel *et al.* showed that high-intensity trainings such as intensive cycling is related to increased level of 25-hydroxyvitamin D 25(OH)D compared to other trainings.[8,9]

On the other hand, childhood obesity which has been dramatically increased in recent years can aggravate vitamin D deficiency through several mechanisms.[7] Moreover, obese people need higher doses of vitamin D to achieve the same serum 25(OH)D as normal weight.[10] So, it is challenging to find proper recommendations to keeping the serum level of vitamin D in obese children at an optimum. Overweight and

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obese children are unlikely to have long-term activities. It is possible that intensive interval trainings can be a suitable substitute for long-term trainings to improve vitamin D status. However, how much these training programs would be effective on the vitamin D deficiency in vulnerable age groups such as children and youth is an issue which needs more comprehensive studies. So, this study aimed to investigate the effects of 8 weeks high-intensity interval training (HIIT) on plasma vitamin D level in overweight male adolescents in Iran.

## Materials and Methods

### Study population

This study was a two-arm randomized controlled trial. A total of 100 adolescent students (12–15 years) were selected from two male high schools in Tehran, Iran. They were randomly assigned as the intervention school ($n$ = 50) and the control school ($n$ = 50). Sample size was estimated using an online tool (http://www.openepi.com/) and based on the previous studies.[11] One hundred students enrolled for blood sampling at baseline and week 18, and 96 students (52 students in the intervention school and 44 students in the control school) provided both baseline and 8th week blood samples.

Participants' height was measured using a tape meter which was connected to the wall. Bioelectrical Impedance Analyzer (BIA)[1] scale (Omron BF511, Kyoto, Japan) was used to measure weight, body mass index (BMI), body fat percentage (%BF), and skeletal muscle percentage (%SM) after entering their age, gender, and height. The validity of this device has been confirmed in a previous study.[12]

### Intervention

Participants in the intervention group performed HIIT training for 3 days per week for 8 weeks and the control group students were asked to walk in the same conditions in the school yard during the intervention times. Considering HIIT pattern, students performed pre-determined physical trainings for 40 min in the school yard after warm up, included 10-min stretch and aerobic exercise, students were divided into four-member groups. They ran 1 min with the most speed for 10 turns in a going round way and they rest after the last round. At the end, 10 min cool down were done. These training got intensive after each week according to pre-determined protocol.[13] All participants were examined for body weight, body composition, and the level of vitamin D at the baseline at the end of the study. The exercise training programs are presented in Table 1.

### Laboratory measurements

About 5 ml blood samples were collected from all participants in the study at baseline and 48 h after the last training session. A direct competitive enzyme-linked immunosorbent assay (ELISA) method and vitamin D VIDAS Kit (Marcy-l'Étoile, bioMérieux, France) were used for measuring 25(OH)D level. The VIDAS 25-OH Vitamin D Total assay is considered suitable for the assessment of vitamin D status and detects both vitamin $D_2$ and $D_3$ for reliable results. Correlation of achieved data by the VIDAS kit with reference methods (chromatography/volumetric spectrometry) was $r$ = 0.93 which is reason of high effectiveness of this method. Inter- and intra-assay coefficients of variation of vitamin D ELISA kits were 6.8% and 7%, respectively. About <20 ng vitamin D/ml plasma was considered as deficiency, between 20–30 ng/dl as insufficient, 30–100 ng/dl as sufficient, and more than 100 ng/dl was considered as toxic.[13] For adjusting the confounding factors, physical activity level and food intake data were assessed using a physical activity tracker (Xiami Mi band 1 plus) and a validated semi-quantitative food frequency questionnaire (FFQ), respectively.

### Statistical analysis

All values are reported as mean ± SEM. Independent t-test was used to compare intervention and control groups at baseline. Furthermore, general linear model repeated measures was used to compare the level of vitamin D changes of students in the intervention school with the control school's students considering both between groups and within (before and after in each group) groups differences together. Normal distribution of dependent variables was assessed by the Shapiro–Wilk test. Data were analyzed with the SPSS for Windows (version 16.0, SPSS Inc., Chicago, IL, USA). A $P$ value of <0.05 was considered significant in all cases.

### Ethics statement

The study was approved by the Ethics Committee of the National Nutrition and Food Technology Research Institute, Tehran, Iran (reference number: Ir.sbmu.nnftri.rec. 1394.22). The details of the study were explained to students and their parents with explanatory letter and written informed consent was obtained from parents and students prior to joining the project.

## Results

The mean age was 14 years (±0.99 in the intervention group and ± 1.55 in the control group). The mean of vitamin D level in both groups was at the normal range at baseline. Amount of age, anthropometric measurements, dietary intake of vitamin D, physical activity, and plasma vitamin D level at baseline were shown in Table 2. No significant difference was observed between two groups.

The data on the effect of HIIT training on plasma level of vitamin D showed that vitamin D level in the intervention group increased significantly compared to the control group and compared to the baseline ($P$ = 0.003, $F$ = 9.7) [Table 3]. The mean of vitamin D level was increased to 1.21 ng/dl in the intervention group, whereas it decreased to 1.94 ng/dl in the control group [Table 2]. However, the second half of the study period coincided with the school exams. Students are likely to reduce their exposure to sunlight due to increased

[1]This device is a digital, mobile, and non-aggressive device that have eight electrodes that sends an extremely weak electrical current of 50 kHz and <500 πA through the body to determine the amount of fat tissue.

**Table 1: High-intensity interval training protocol**

| Weeks | Warm-up (min) | HIIT training (main activity min) | Interval (min) | HIIT training (main activity min) | Cool down (min) | Total activity time (main activity, warming up, and cooling down) (min) |
|---|---|---|---|---|---|---|
| 1 | 10 | 1 | 4 | 2 | 5 | 25 |
| 2 | 10 | 1 | 4 | 3 | 5 | 30 |
| 3 | 10 | 1 | 4 | 4 | 5 | 35 |
| 4 | 10 | 1.5 | 4 | 2 | 5 | 26 |
| 5 | 10 | 1.5 | 4 | 3 | 5 | 31.5 |
| 6 | 10 | 1.5 | 4 | 4 | 5 | 37 |
| 7 | 10 | 2 | 5 | 3 | 5 | 36 |
| 8 | 10 | 2 | 4 | 4 | 5 | 43 |

**Table 2: Characteristic of participant students in the study at baseline ($n$=96)**

| | Mean (±SD) | | *P* |
|---|---|---|---|
| | Intervention group | Control group | |
| Year (age) | 14 (±0.99) | 14 (±1.55) | 0.29 |
| Weight (kg) | 72.92 (±14.21) | 73.11 (±11.97) | 0.94 |
| Height (m) | 1.66 (±8.03) | 1.68 (±8.12) | 0.22 |
| BMI (kg/m$^2$) | 26.13 (±4.45) | 25.7 (±2.95) | 0.59 |
| BF% | 26.91 (±7.49) | 26.33 (±6.16) | 0.7 |
| SM% | 35.18 (±2.74) | 35.72 (±2.51) | 0.34 |
| Dietary vitamin D intake (ng/day) | 11.36 (±1.32) | 11.29 (±0.97) | 0.49 |
| Physical activity (min/day) | 1270 (±283) | 1064 (±97) | 0.34 |
| Plasma vitamin D level (ng/ml) | 39.78 (±15.23) | 42.84 (±14.75) | 0.34 |

SM%=Skeletal muscle percentage, BF%=Body fat percentage, BMI=Body mass index

**Table 3: Effect of intervention on vitamin D level and anthropometric index using repeated measures ($n$=96) (df=1)**

| | The intervention group | | The control group | | Group × time | |
|---|---|---|---|---|---|---|
| | At baseline | After 8 weeks | At baseline | After 8 weeks | *F* | *P* |
| Vitamin D (ng/ml) | 39.78 (±15.23) | 40.99 (±16.14) | 42.48 (±14.75) | 40.9 (±16.81) | 9.7 | 0.003 |

time of study.

## Discussion

The results of this study identified that the HIIT has an effect on vitamin D level compared to walking. Some other studies have reported a positive effect of HIIT on vitamin D level[14,15] which were consistent with our findings. Kluczynski *et al*. reported positive associations between 25(OH)D levels and physical activity.[3] Another study reported that physical activity was positively associated with 25(OH)D in women.[6]

The exact mechanism of such effects is unknown. It is possible that physical activity indirectly influences vitamin D concentration by inducing hormonal changes.[11,16] Although, the effect of physical activity on vitamin D concentrations can be induced by exposing with sunlight during performing training outdoors.[6] For adjusting this effect in the present study, the control subjects were asked to walk in the same conditions during the training time.

Results of other studies indicate that moderate physical activity is related with increase in bone mineral density or BMD in youth men compared to sedentary people.[17] These effects in bone density and calcium density can be caused by increase in plasma active form of vitamin D (calcitriol) and increase of calcium intestinal absorption. People with physical training are reported to have more calcium absorption compared to people with sedentary lifestyle.[18]

On the other hand, increase of calcitriol as a result of exercise training can be reached by contemporary and short-term decrease of blood calcium level (e.g., losses of calcium as a result of sweating during the intensive exercise). Sweat calcium concentration varies from 52 to ultimate 203 mg/l in athletes[18,19] that can lead to initiate parathyroid hormone (PTH) releasing and finally results in calcitriol production.

Inconsistent with our studies, Zittermann *et al*. reported that the level of calcitriol was decreased after 4 weeks of training.[17] If the serum level of calcium increased significantly, a negative feedback resulted by increased level of calcium may lead to decreased level of vitamin D in a short period of time.

There are some limitations in the present study. Only male adolescents participated in this study, so there was no possibility for analysis of changes related to sex and age. So, the results would not apply to females and other age groups. Also the duration of the intervention was 8 weeks that may not reflect the effects of HIIT on vitamin D levels in a long period.

## Conclusion

About 8 weeks of high-intensive training significantly increased 25(OH)D in 12–16-year-old overweight male adolescents. Further studies including both the sex, other age groups, and with longer interventions are crucial to have a better understanding of the interaction between physical activity and the level of vitamin D.

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### Conflicts of interest

There are no conflicts of interest.

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